DANISH EMISSION INVENTORIES FOR AGRICULTURE

Inventories 1985–2023

Scientific Report from DCE – Danish Centre for Environment and Energy No. 696 2026

AARHUS UNIVERSITY
DCE – DANISH CENTRE FOR ENVIRONMENT AND ENERGY

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Abstract: Regulations in international conventions obligate Denmark to prepare annual emission inventories and document the methodologies used to calculate emissions. The responsibility for preparing the emission inventories for agriculture is undertaken by the Danish Centre for Environment and Energy (DCE), Aarhus University, Denmark. This report contains a description of the emissions from the agricultural sector from 1985 to 2023 and includes a detailed description of methods and data used to calculate the emissions, which is based on international guidelines as well as national methodologies. Emissions are calculated for both greenhouse gases and air pollutions. The agricultural NH_3 emission from 1985 to 2023 has decreased from 162 tonnes NH_3, corresponding to a reduction of approximately 61 %. The emission of greenhouse gases in 2023 is estimated at 11.2 million tonnes CO_2 equivalents and reduced from 15.3 million tonnes CO_2 equivalents in 1985. Since 1990, which is the base year of the Kyoto Protocol, a reduction of 23 % is obtained.

Keywords: Agriculture, NH_3, N_2O, ammonia, methane, nitrous oxide, Particulate matter, greenhouse gas, inventory, inventories, Denmark

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Preface

On behalf of the Danish Ministry of Environment and Gender Equality and the Ministry of Climate, Energy and Utilities, the Danish Centre for Environment and Energy (DCE) at Aarhus University (AU) is responsible for the calculation and reporting of the Danish national emission inventories. The inventories are compiled to fulfil Denmark's obligations under EU directives, the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Economic Commission for Europe's Convention on Long Range Transboundary Air Pollution (UNECE CLRTAP). This documentation report for calculated agricultural emissions has been externally reviewed as a key part of the general national inventory QA/QC plan.

This report has been reviewed by Tommy Dalgaard, professor at Department of Agroecology, Aarhus University.

Summary

International conventions obligate Denmark to prepare annual emission inventories and document the methodologies used to calculate emissions. The responsibility for preparing the emission inventories for agriculture in Denmark is undertaken by DCE - the Danish Centre for Environment and Energy at Aarhus University (AU). This report includes a detailed description of methods and data used to calculate the emissions from the agricultural sector and is an updated version of DCE Scientific Report No. 443 published in 2021.

The emissions from the agricultural sector include the greenhouse gases: methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2), as well as the air pollutants: ammonia (NH_3), particulate matter (PM), non-methane volatile organic compounds (NMVOC), nitrogen oxides (NO_x), hexachlorobenzene (HCB) and other pollutants specifically related to the field burning of agricultural residues such as carbon monoxide (CO), sulphur dioxide (SO_2), heavy metals, dioxins, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). In this context, the agricultural sector is to be understood as defined by the UNFCCC (United Nations Framework Convention on Climate Change), which means that emissions related to vehicles and other machinery used in the agricultural production are included in the energy sector, while emissions and uptake of carbon in soil are included in the LULUCF sector (Land-Use, and Land-Use Change and Forest).

The agricultural emissions are calculated by using the data-based model *Integrated Database model for Agricultural emissions* (IDA). The model covers all aspects of the agricultural inputs and estimates both greenhouse gases and air pollutants. The largest contribution to agricultural emissions originates from livestock production and most of the input data are sourced from Statistics Denmark, DCA - Danish Centre for Food and Agriculture, Aarhus University, SEGES Innovation and the Agency for Green Transition and Aquatic Environment, and Danish Agricultural and Fisheries Agency. These data include the extent of the livestock production, land use, use of inorganic fertilisers, Danish standards for feed consumption and the content of nitrogen and dry matter in the excreted manure. The emission inventories reflect the actual conditions for the Danish agricultural production. In cases where no Danish data are available, default values recommended by the Intergovernmental Panel on Climate Change (IPCC) and the European Monitoring and Evaluation Programme (EMEP) are used.

The agricultural sector is the main contributor of the NH_3 emission and accounts for approximately 95 % of the total NH_3 emission in 2023. Most of the ammonia emissions are related to the livestock production (animal manure) and mainly from the production of swine and cattle. The agricultural NH_3 emission accounts for 162 kt (kilo tonnes) NH_3 in 1985 decreasing to 63 kt NH_3 in 2023, corresponding to a reduction of approximately 61 %. Improvements in feed efficiency, improvement of the utilisation of nitrogen in livestock manure combined with a significant decrease in the consumption of inorganic N fertiliser, are the most important explanations for the reduction of the NH_3 emission.

The revised Gothenburg Protocol under the UNECE (United Nations Economic Commission for Europe) Convention on Long-Range Transboundary

Air Pollution (CLRTAP) introduced an adjustment mechanism, so that inventories could continue to evolve, e.g. by introducing new emission sources or updating methodologies. Regarding the emission of NMVOC, Denmark has applied for and been granted adjustments. The adjustments are related to the NMVOC emission from manure management for dairy cattle, which is an emission source introduced in the EMEP/EEA Guidebook in 2013.

The agricultural emission of greenhouse gases (GHG) contributes with approximately 29 % of the total GHG from Denmark in 2023. The emission is closely related to the livestock production, and especially the CH_4 emission from the enteric fermentation process, which accounts for 35 % of the total agricultural GHG emission in 2035, and is mainly related to cattle production.

The GHG emission from the agricultural sector is estimated to 15.3 million tonnes CO_2 equivalents in 1985, decreasing to 11.2 million tonnes CO_2 equivalents in 2023. Since 1990, which is the base year of the United Nations Framework Convention on Climate Change, where the emission was 14.6 million tonnes CO_2-eqv. a reduction of 23 % is obtained in 2023. The main reason for the reduced GHG-emission is decrease in emission of N_2O where the main driver is improved utilisation of nitrogen in animal manure, mainly forced by environmental regulation and consequently a reduction in the amount of inorganic N fertilisers used. Another important decreasing driver is a decrease in number of cattle, and thus a decrease in CH_4 emission from enteric fermentation and frequent removal of slurry from barns for fattening pigs and biogas treatment of slurry which both decreases the emission from manure management.

Sammenfatning

Danmark har via konventioner forpligtet sig til årligt at opgøre udledninger af drivhusgasser og luftforurenende stoffer. Udarbejdelsen af de årlige danske emissionsopgørelser og dokumentationen for hvorledes emissionerne opgøres, varetages af DCE - Nationalt Center for Miljø og Energi ved Aarhus Universitet (AU). Nærværende rapport er en metodebeskrivelse af beregning og anvendt datagrundlag for opgørelse af udledninger fra landbrugssektoren. Denne metodebeskrivelse opdateres jævnligt, og denne rapport er en opdatering af DCE videnskabelig rapport nr. 443 publiceret i 2021.

Rapporten omfatter en opgørelse af landbrugets emissioner i perioden 1985 – 2023 af drivhusgasserne: Metan (CH_4), lattergas (N_2O) og kuldioxid (CO_2) og luftforureningskomponenterne: Ammoniak (NH_3), partikler (PM), flygtige organiske forbindelser (NMVOC), kvælstofilter (NO_x), hexaklorbenzen (HCB) og andre stoffer, der er relateret til markafbrænding af afgrøderester fra landbruget, som kulilte (CO), svovldioxid (SO_2), tungmetaller, dioxiner, polycykliske aromatiske kulbrinter (PAH'er) og polyklorerede bifenyler (PCB'er). Landbrugssektoren skal i denne sammenhæng forstås, som defineret i UNFCCC (United Nations Framework Convention on Climate Change), mens udledninger relateret til køretøjer og øvrigt maskineri er inkluderet i energisektoren, mens udledning og optag af kulstof i jord er inkluderet i LULUCF sektoren (Land-Use, and Land-Use Change and Forest).

Landbrugets emissioner er beregnet på grundlag af en databasebaseret model kaldet IDA (Integrated Database model for Agricultural emissions). Størstedelen af emissionerne er relateret til husdyrproduktionen og langt de fleste inputdata er hentet fra Danmarks Statistik, DCA - Nationalt Center for Fødevarer og Landbrug ved Aarhus Universitet og SEGES Innovation, samt offentlige styrelser; dels Styrelsen for Grøn Arealomlægning og Vandmiljø og dels Styrelsen for Fødevarer, Landbrug og Fiskeri. Disse data omfatter bl.a. omfanget af husdyrproduktionen, arealanvendelse, handelsgødningsforbruget, normdata for foderindtag og dyrenes tørstof- og kvælstofudskillelse via husdyrgødningen, som er nogle af de vigtigste parametre for emissionsberegningen. Emissionsopgørelsen tager således højde for disse faktiske forhold, der gør sig gældende for den danske landbrugsproduktion. For de forhold, hvor der ikke forefindes nationale data, anvendes standardværdier fra IPCC - The Intergovernmental Panel on Climate Change og EMEP - The European Monitoring and Evaluation Programme.

Langt størstedelen af den samlede NH_3-emission, svarende til ca. 95 %, kan henføres til landbrugsproduktionen. Ammoniakemissionen sker i forbindelse med omsætningen af kvælstof og størstedelen af emissionen kommer fra husdyrgødning, hvor produktionen af svin og kvæg er de største bidragydere hertil. Ammoniakemissionen fra landbrugssektoren er fra perioden 1985 til 2023 faldet fra 162 kilotons (kt) NH_3 til 63 kt NH_3, svarende til en reduktion på 61 %. De væsentligste årsager til reduktionen er en forbedring i fodereffektivitet, en bedre udnyttelse af kvælstofindholdet i husdyrgødningen og på baggrund heraf, et markant fald i anvendelsen af kvælstof i handelsgødning.

Det reviderede Göteborg-protokol under UNECE's konvention om langtransporteret grænseoverskridende luftforurening (CLRTAP) introducerede en justeringsmekanisme, så emissionsopgørelser løbende kunne udvikle sig, f.eks.

ved at indføre nye emissionskilder eller opdatere metoder. Danmark har under denne justeringsprocedure ansøgt og fået godkendt justeringer for NMVOC-emission fra håndtering af husdyrgødning for malkekvæg, både under CLRTAP og under NECD, fordi denne emissionskilde først blev inkluderet i EMEP/EEA Guidebook i 2013.

Landbrugets emissioner af drivhusgasser (GHG) bidrager med 29 % af den totale GHG-emission fra Danmark i 2023. Størstedelen af emissionen er knyttet til husdyrproduktionen og særligt fra kvægs fordøjelsesprocesser, som bidrager med 35 % af den samlede GHG-emission fra landbruget i 2023.

I 1985 er GHG-emissionen fra landbrugssektoren opgjort til 15,3 mio. tons CO_2-ækvivalenter og er frem til 2023 faldet til 11,2 mio. Siden 1990, som er klimakonventionens basisår, hvor emissionen var 14,6 mio. tons CO_2-ækvivalenter, er emissionen frem til 2023 faldet med 23 %. Den mest betydende årsag til reduktion af GHG-emissionen er emission af N_2O, hvor øget anvendelse af kvælstofindholdet i husdyrgødningen og dermed betydeligt fald i anvendelsen af handelsgødning, som følge af miljøreguleringen for at undgå unødigt tab af kvælstof til omgivelserne (luft, jord og vand). En anden forklaring er faldet i antallet af kvæg, som har betydet et væsentligt fald i CH_4-emissionen fra fordøjelse, samt hyppig udslusning af gylle fra slagtesvinestalde og biogas behandling af gylle, som begge reducerer emissionen fra husdyrgødning.

1 Introduction

As a signatory to international conventions Denmark is under obligation to prepare annual emission inventories for a range of pollutants. For agriculture, the relevant emissions to be calculated are ammonia (NH_3), the greenhouse gases (GHG): methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2), and other pollutants such as non-methane volatile organic compounds (NMVOC), particulate matter (PM), nitrous oxide (NO_x), hexachlorobenzene (HCB) and a series of other pollutants related to the burning of crop residues on fields such as carbon monoxide (CO), sulphur dioxide (SO_2), heavy metals, dioxins, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). DCE – Danish Centre for Environment and Energy at Aarhus University is responsible for calculating emissions and reporting the annual emission inventories. The primary data are collected from Statistics Denmark, DCA - Danish Centre for Food and Agriculture at Aarhus University, SGAV - Agency for Green Transition and Aquatic Environment and LFST - Danish Agricultural and Fisheries Agency. In addition to the reporting of emission data, Denmark is obligated by the conventions to document the calculation methodology. This report includes both a review of the emissions for the period 1985–2023 and a description of the methodology on which calculation of emissions is based. The report is an updated version of Scientific Report from DCE – Danish Centre for Environment and Energy No. 443 (Albrektsen et al., 2021).

In 2023, 95 % of the total NH_3 emission in Denmark came from the agricultural sector, the remainder 5 % is mainly from transport. Emissions are reported under the 1999 Gothenburg Protocol, under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP), and the EU's NEC Directive on national emission ceilings (2016/2284/EU) CLRTAP. For emission of NMVOC reported under UNECE the emissions include an adjustment for emission from manure management.

In 2023, the agricultural sector contributed 29 % to the total emission of greenhouse gases in Denmark, measured in CO_2 equivalents (CO_2-eqv.). The relatively large contribution is due to the emission of CH_4 and N_2O. These gases have a higher global warming effect than CO_2. In Decision 18/CMA.1 (UNFCCC, 2018) it is decided that the 100-year time-horizon global warming potential (GWP) values from the IPCC Fifth Assessment Report (AR5) shall be used to report aggregated emissions and removals of GHGs, expressed in CO_2 equivalents. In AR5 (IPCC, 2013) Chapter 8, Table 8.7 are the 100-year GWP for CH_4 and N_2O given and show that these are 28 and 265 times stronger than that of CO_2, respectively.

The IPCC has developed guidance documents on how greenhouse gas emissions should be calculated. The relevant documents for agriculture currently used under the UNFCCC is the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) and IPCC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2019). The guidelines are prepared for use in all countries based on a division of different climatic regions into different geographic locations. The guidelines, however, do not always represent the best method at the level of the individual country due to the different national circumstances for climate and agricultural conditions. The IPCC, therefore, advocates the use, as far as possible, of national figures where data are available.

Agricultural emissions are calculated in an integrated national model complex IDA - Integrated Database model of Agricultural emissions. This means that the calculation of emissions of NH_3, greenhouse gases and other pollutants is based on the same activity data, i.e. the number of livestock, the distribution of types of livestock barns, fertiliser type, land use, etc.

The emission inventories are continuously being improved with the availability of new knowledge and therefore, over time, changes in estimated emissions can take place to reflect the new knowledge. It is a priority to use national data if these are available to reflect the Danish agricultural and climate conditions. This causes high requirements for documentation of data, especially in areas where the methodology and the national data differ significantly from the IPCC's recommended standard methods or data values.

The current report includes an introductory overview of emission from year 1985 and forward to the recent reported emission year 2023 and describing the changes in agricultural activities that have influenced the emissions. This is followed by a description of the IDA model used to calculate the emissions, and a detailed description is provided on how the emissions for the individual pollutants are calculated.

2 Trends in agricultural emissions 1985-2023

This chapter describes the development in the agricultural emissions of air pollution and greenhouse gases from 1985 to 2023. The first group includes pollutants involved in air pollution, i.e. ammonia (NH_3), nitrogen oxides (NO_x), particulate matter (PM), non-methane volatile organic compounds (NMVOC) and other air pollutants (SO_2, CO, heavy metals, PAHs, dioxins, PCBs and HCB), which all must be reported under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). Emissions of other air pollutants are related to the field burning of agricultural residues and HCB also relates to use of pesticides. The second group includes the direct greenhouse gases, which must be reported to UNFCCC related to the Climate Convention and EU Regulation 2018/1999 on the Governance of the Energy Union and Climate Action. The direct greenhouse gases are methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2). Pollutants that have an indirect effect on greenhouse gas emissions, i.e. NMVOC and NO_x from animal manure and cultivated crops, carbon monoxide (CO) and sulphur dioxide (SO_2) from field burning, must be estimated and reported to both the UNFCCC and the CLRTAP. Table 2.1 gives an overview of the conventions, the required reporting format and which pollutants they cover.

Table 2.1 Overview of conventions and pollutants.

Convention	Report format	Pollutants
The United Nations Framework Convention on Climate Change (UNFCCC), including the Paris Agreement.	Data: CRT (Common Reporting Tables) Report: NID (National Inventory Document)	Direct greenhouse gases; CH_4, N_2O, CO_2[1] Indirect greenhouse gases; NMVOC, NO_x, CO, SO_2[1]
EU Regulation 2018/1999 on the Governance of the Energy Union and Climate Action	Same as UNFCCC	Same as UNFCCC
The UNECE Convention on Long-Range Transboundary Air Pollution. Including 8 protocols.	Data: NFR (Nomenclature For Reporting) Report: IIR (Informative Inventory Report)	Main pollutants; NH_3, NO_x NMVOC, SO_2 Particulate matter; TSP, PM_{10}, $PM_{2.5}$, BC Other pollutants; CO Priority metals; Pb, Cd, Hg Other metals; As, Cr, Cu, Ni, Se, Zn PAHs; (Benzo(a)pyrene, Benzo(b)fluoranthene, benzo-(k)fluoranthene, Indeno(1,2,3-cd)pyrene) Dioxins and furans (PCDD/-F) Polychlorinated biphenyls (PCBs) Hexachlorobenzene (HCB)
EU's Directive on national emission ceilings (NECD) (2016/2284/EU)	Same as UNECE Convention	Same as UNECE Convention

[1] In the present CRT format it is not possible to report CO_2 and SO_2 from field burning of agricultural residues.

It must be noted that CO_2 removals/emissions from agricultural soils are not included in the emission inventories for the agricultural sector. According to the IPCC guidelines this removal/emission should be included in the LULUCF sector (Land-Use, Land-Use Change and Forestry). Emissions related to agricultural machinery (tractors, harvesters and other non-road machinery) are reported in the energy sector.

2.1 Air pollutants

Table 2.2 shows the agricultural contribution of emissions to the national total in 2023. The main part of the NH_3 emission (95 %) and TSP emission (77 %) is related to the agricultural sector. For the remaining compounds, the agricultural sectors share is within the range from less than 1 % up to 46 %.

Table 2.2 Emissions of ammonia (NH_3), particulate matter (TSP, PM_{10}, $PM_{2.5}$), non-methane volatile organic compounds (NMVOC), sulphur oxides (SO_x) and nitrogen oxides (NO_x) in 2023, reported to UNECE, January 2025.

	NH_3	TSP	PM_{10}	$PM_{2.5}$	NMVOC	SO_X	NO_X
National total, kt	66	82	21	11	98	8	81
Agricultural total, kt	63	63	8	1	45	<1	17
Agricultural part of national total, %	95	77	38	9	46	<1	21

2.1.1 NH_3

Approximately 95 % of the total NH_3 emission originates from the agricultural sector and the remainder is mainly from transport. Approximately 68 % of the NH_3 emissions from agricultural activities relates to livestock production, the remaining 32 % from the use of inorganic N fertiliser, cultivated crops, crop residue, NH_3 treated straw, the field burning of agricultural residues, sewage sludge and other organic fertiliser applied to fields as fertiliser.

Figure 2.1 shows the emissions divided into the different sources. The emission of ammonia from the agricultural sector decreased from 162 kt NH_3 in 1985 to 63 kt NH_3 in 2023, which corresponds to a 61 % reduction.

The significant decrease in NH_3 emissions is strongly correlated to a decreasing emission from livestock production, which is determined by lower feed costs for the farmers and environmental requirements for the farmer's handling of livestock manure. During the last 30 years, a string of measures have been introduced by action plans to prevent the loss of nitrogen from agriculture to the aquatic environment, for example the NPO (Nitrogen, phosphor, organic matter) Action Plan (1986), Action Plans for the Aquatic Environment (1987, 1998, 2004), the Action Plan for Sustainable Agriculture (1991), the Ammonia Action Plan (2001), environmental Approval Act for Livestock Holdings (2007/2011) and agreement on the Green Growth (2009/2010). These action plans and initiated measures have brought about a decrease in animal nitrogen excretion, improvement in use of nitrogen in manure and a fall in the use of inorganic N fertiliser, all of which have helped reduce the overall NH_3 emission significantly.

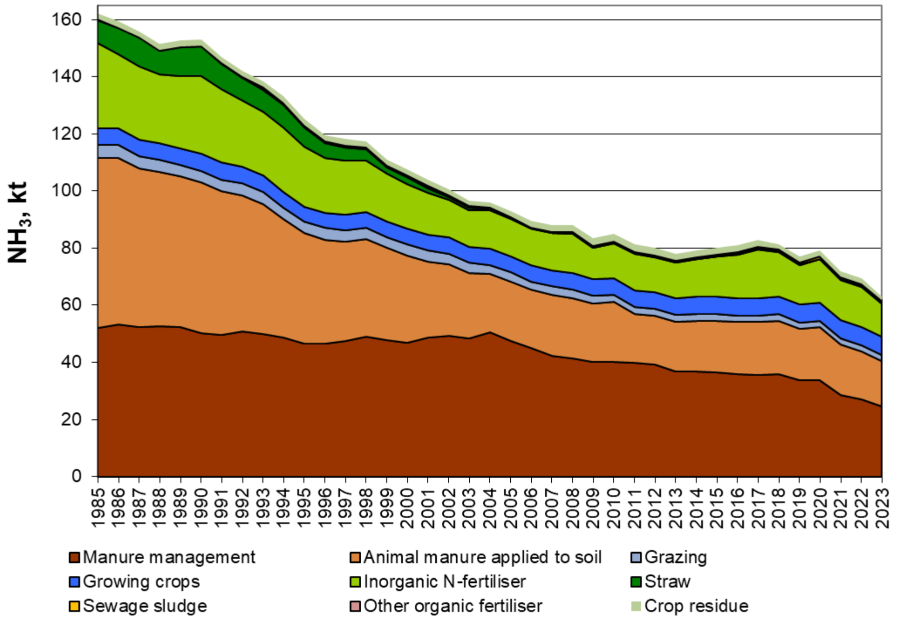

Figure 2.1 NH_3 emissions in the agricultural sector, 1985 to 2023. Straw includes NH_3 treated straw and field burning of agricultural residues. Other organic fertiliser includes industrial waste and biomass (other than manure) from biogas facilities.

In Appendix A, the trend for NH_3 emission from 1985 to 2023 from different sources is expressed in both NH_3-N and NH_3, and in Appendix B emission from animals shown for cattle, swine, poultry and other animals are divided into emission from barns, storage, application and grazing.

NH_3 emission from manure management

In 2023, manure management contributed by 39 % to the total NH_3 emission from agriculture. From 1985 to 2023, the emission from manure management has decreased by 53 %.

Figure 2.2 shows the annual NH_3 emissions from the main livestock categories. Most of the emission from manure originates from the production of swine and cattle. In 1985, approximately 60 % of the emission was related to the swine production, while 25 % was related to the cattle production. In 2023, the contribution from cattle production has increased to 43 % and the swine production accounted for also 43 %. A decrease in emission from other livestock are seen in 2021 and this is due to culling of all mink in Denmark, during the COVID-19 pandemic, to mitigate spread of SARS-CoV-2. All animals were put down at the end of 2020.

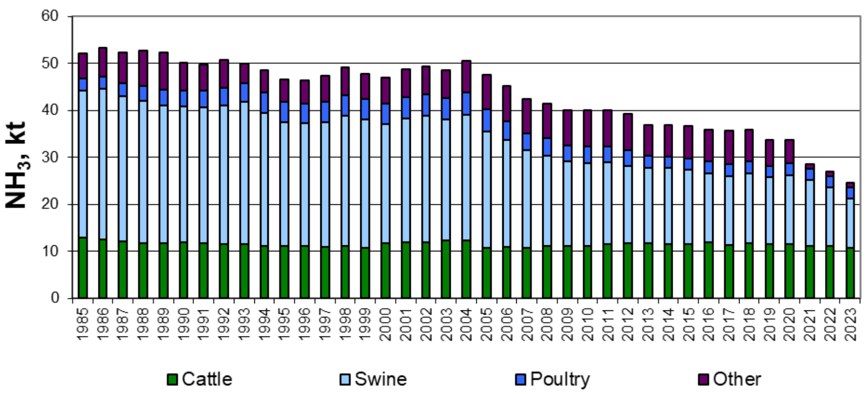

Figure 2.2 NH_3 emissions from manure management are divided into different livestock categories. ‘Other’ includes fur bearing animals, horses, sheep, goats and deer.

The emission from manure management decreased from 1985-2023 for both cattle and swine. The emissions from swine have decreased by 66 % despite an increase in the production of fattening pigs from 14.6 million produced in 1985 to 15.3 million in 2023. One of the most important reasons for this is the improvement in feed efficiency. In 1985, the nitrogen excretion in manure for one produced fattening pig was estimated to 5.09 kg N (Poulsen & Kristensen, 1997). In 2023, that figure was considerably lower at 2.56 kg N per fattening pig produced (Børsting & Hellwing, 2024). Due to the large contribution from the pig production, the lower level of N excretion has a significant influence on total agricultural emissions. For cattle, the emissions have decreased 17 % mainly due to decrease in number of cattle. As mentioned above, all fur animals (mink) were culled at the end of 2020 and a general ban on mink breeding was established in 2021 and later extended until 31 December 2022, so no emission is occurring from fur animals in 2021-2022. In 2023, the production of mink started up slowly, but with a low number of animals compared to before 2021.

Figure 2.3 shows the different emission sources, i.e. from manure handling in animal barns, manure storage, application to fields and from grazing animals. The overall decrease is a consequence of the general requirement to improve the utilisation of nitrogen in the manure - e.g. requirements to a larger part of the nitrogen in manure must be included in the farmers' nitrogen accounting. This has led farmers to consider the manure as a nitrogen resource instead of a waste product. Especially the emission from application and storage of manure has decreased significantly.

Regarding the field application of animal manure, considerable changes have taken place over the period. From the beginning of the 1990s, slurry has increasingly been spread using trailing hoses, and an increasing proportion of livestock manures goes to slurry. Furthermore, since the late 1990s, the practice of slurry injection or mechanical incorporation into the soil has increased. For 2018, it is estimated that 89 % for cattle slurry and 43 % for swine slurry is applied using injection/incorporation techniques (Birkmose, 2020). This development is in addition to general environmental requirements also a consequence of a ban on broad spreading from 2003. From 2011, slurry applied on fields with grass for feeding or fields without crop cover, must be injected directly into the soil. However, the injection requirements are not required if the slurry has been acid treated before application to soil.

From 2005, a considerable decrease in the emission from storage is seen, which is due to the requirement to cover manure heaps.

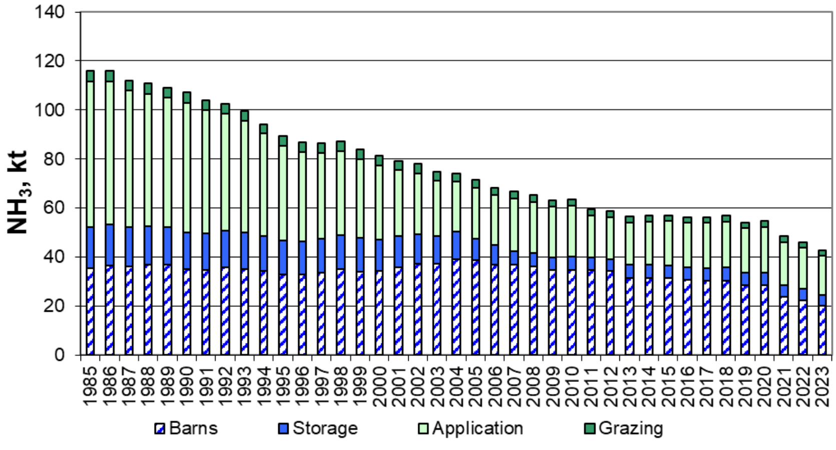

Figure 2.3 NH_3 emissions from animal manure, 1985 to 2023.

NH_3 emissions from agricultural soils

In 2023, NH_3 emissions related to agricultural soils contributed 32 % to total agricultural emissions, and this mainly stems from animal manure applied to soil, the use of inorganic N fertiliser and from cultivated crops as shown in Figure 2.4.

The Danish inventories include the emission from cultivated crops. No methodological guidance is provided in the EMEP/EEA Guidebook. Studies have demonstrated that growing crops can emit NH_3 (Schjoerring & Mattsson, 2001). Despite the uncertainties related to this emission source due to effect from different geographic and climatic conditions, Denmark has chosen to include the emission and thus avoid an underestimation of NH_3 emission.

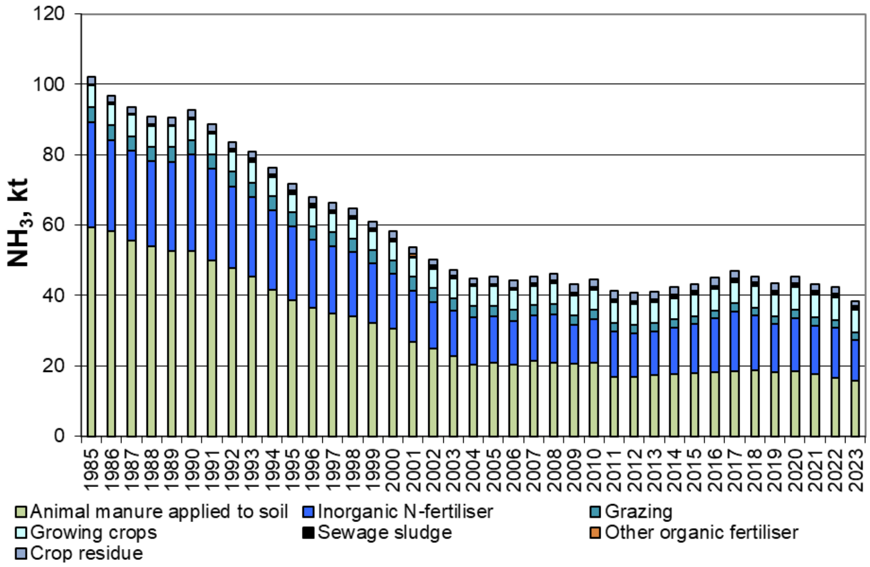

Figure 2.4 NH_3 emission from animal manure applied to soil, inorganic N fertiliser, grazing, cultivated crops, crop residue, sewage sludge and other organic, 1985-2023.

Due to the requirement to improve the utilisation of nitrogen in animal manure, the use of inorganic N fertilisers has decreased dramatically. The amount of nitrogen applied to soils from inorganic N fertilisers in 2023 is over 50 % lower compared with the amount used in 1985.

For further description of NH_3 emissions see Chapter 5.

2.1.2 PM

Emission of particulate matter (PM) originates from livestock barns, field operations such as soil cultivation and harvesting, and the field burning of agricultural residues (further description in Chapter 6).

The PM emissions from the agricultural sector mainly consist of larger particles. In the reporting under CLRTAP, PM is reported as the total suspended particles (TSP), PM_{10} and $PM_{2.5}$ (Particulate matter with diameter of less than 10 µm and less than 2.5 µm). TSP emission from the agricultural sector contributes 77 % to the national TSP emission in 2023 and the emission shares for PM_{10} and $PM_{2.5}$ are 38 % and 9 %, respectively. For TSP, 89 % of the total agricultural emission is related to field operations in 2023. The emission from livestock contributes 11 % and the field burning of agricultural residues contributes less than 1 % to the agricultural emission. For PM_{10}, field operations contribute with 70 %, livestock with 29 % and field burning of agricultural residues with 1 %. For emission of $PM_{2.5}$, the sources contribute 41 % from field operations, 51 % from livestock and 8 % from field burning.

Figure 2.5 shows PM emission from the agricultural sector from 1985 to 2023 given in TSP, PM_{10} and $PM_{2.5}$.

Emission from field operations originates from crop harvesting, cultivation of soil, and the cleaning and drying of crops (EMEP, 2023). Harvesting and soil cultivation are the predominant sources of PM. The decrease in emission from field operations from 2001 to 2002 and increase from 2016 to 2017 is due to changes in the number of operations in soil cultivation caused by changes in cultivation practice.

Since 1985, the overall emission from livestock has been almost unaltered. The changes in the total emission for each livestock category mainly reflect the changes in the number of animals but are also affected by the distribution of animals in subcategories and changes in barn type.

The emission from field burning of agricultural residues decreases significantly from 1989 to 1990 due to a ban on burning of these residues. From 1990, the burning of residues may only take place in connection with production of grass seeds on fields with repeated production and in cases of wet or broken bales of straw.

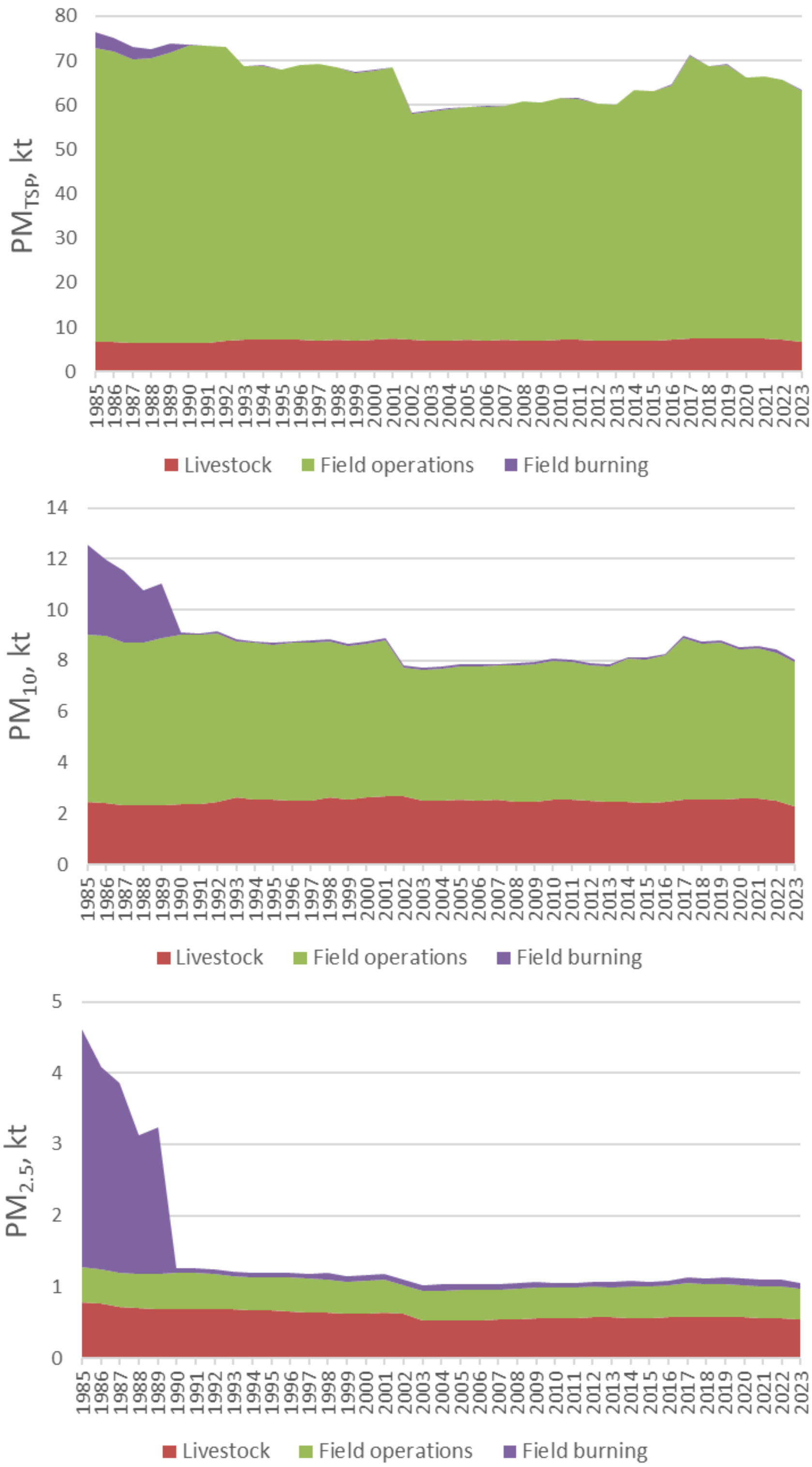

Figure 2.5 Emission of PM, given in TSP, PM_{10} and $PM_{2.5}$ from the agricultural sector, 1985 to 2023.

2.1.3 NMVOC

The NMVOC emission includes emission from livestock, manure applied to soil, grazing, field burning of agricultural residues and from cultivated crops and grass. Agriculture contributed with 45 kt NMVOC in 2023, corresponding to 46 % of the national NMVOC emission. Of this, emission from livestock contribute with 83 %, manure applied to soil with 13 %, crops with 4 % and field burning and grazing less than 1 % in 2023. The NMVOC emission from livestock production is mainly related to dairy cattle, because of silage feeding, where a relatively high NMVOC emission occurs.

The total emission from the agricultural sector has decreased from 1990 to 2023 by 41 %, mainly due to a decrease in emission from manure applied to soil. Calculation of NMVOC emissions from manure applied to soil are based on correlation between NH_3 and many of the different NMVOCs emitted from livestock barns (see Chapter 9.2). The decrease in NMVOC from manure applied to soil is due to decrease in the ratio between emission of NH_3 from manure applied to soil and NH_3 emission from barn.

The greatest part of the emission from livestock originates from cattle. Emission from dairy cattle is almost unaltered from 1985-2023 because while the number of dairy cattle has decreased, the feed intake has increased. The emission from non-dairy cattle decreases over the years due to decease in number of animals.

Emission from grazing follows the trend in grazing days and number of dairy cattle. Emission from crops is affected by the area and distribution of crop types. Emission from field burning decreased significantly in 1990 because field burning of agricultural residues was prohibited.

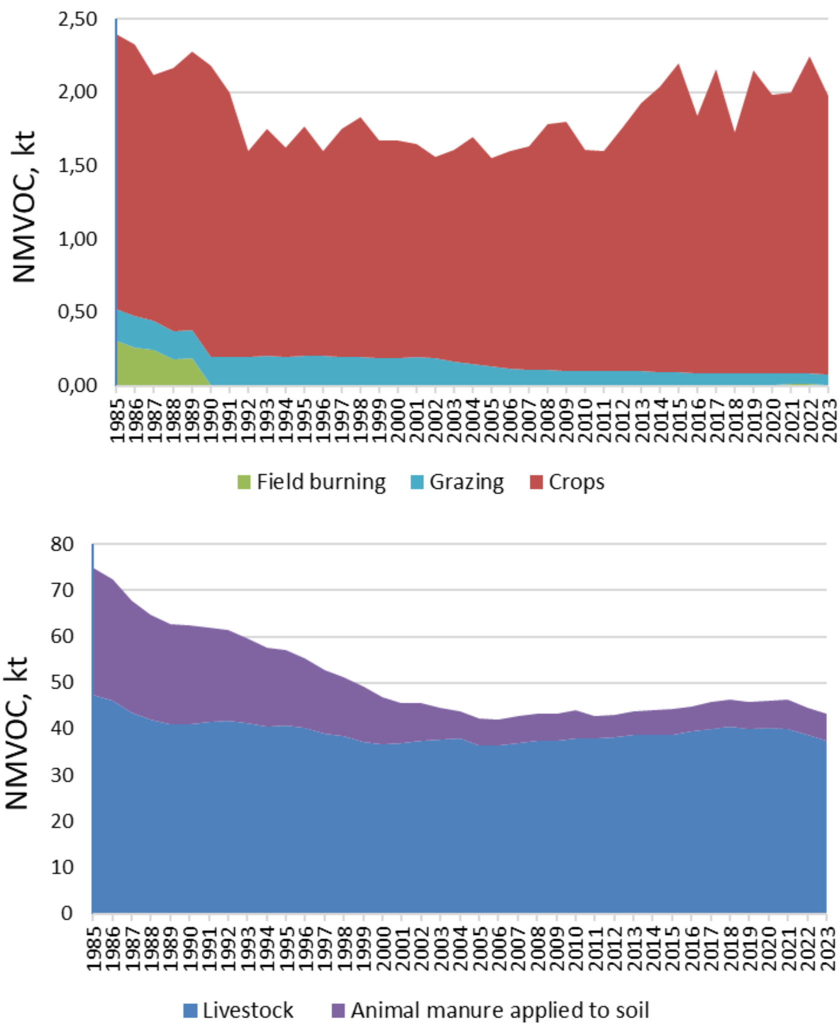

Figure 2.6 Emission of NMVOC from the agricultural sector, 1985-2023.

2.1.4 NO_x

Emission of NO_x, given in NO_2 equivalents, is estimated for animal manure in barn and storage, inorganic N fertiliser, manure applied to soil, grazing, sewage sludge used as fertiliser, other organic fertilisers and from field burning of agricultural residues. Agriculture contributed with 17 kt NO_2 in 2023, corresponding to 21 % of the national NO_2 emission. From 1985, the emission has decreased mainly due to decrease in use of inorganic N fertiliser.

The total emission of NO_x from agricultural sector is decreased by 41 % from 1985-2023 and is mainly due to decrease in emission from inorganic N fertiliser. Emission of NO_x follow the amount of N applied to soil for animal manure applied to soil, inorganic N fertiliser, grazing, sewage sludge and other organic fertiliser (see Chapter 10.2). For emission from manure management are the emission affected by both amount of N excreted and type of manure (see Chapter 10.1). For emission from field burning the emission are based on amount of straw burnt and decrease significantly in 1990 because field burning of agricultural residues was prohibited.

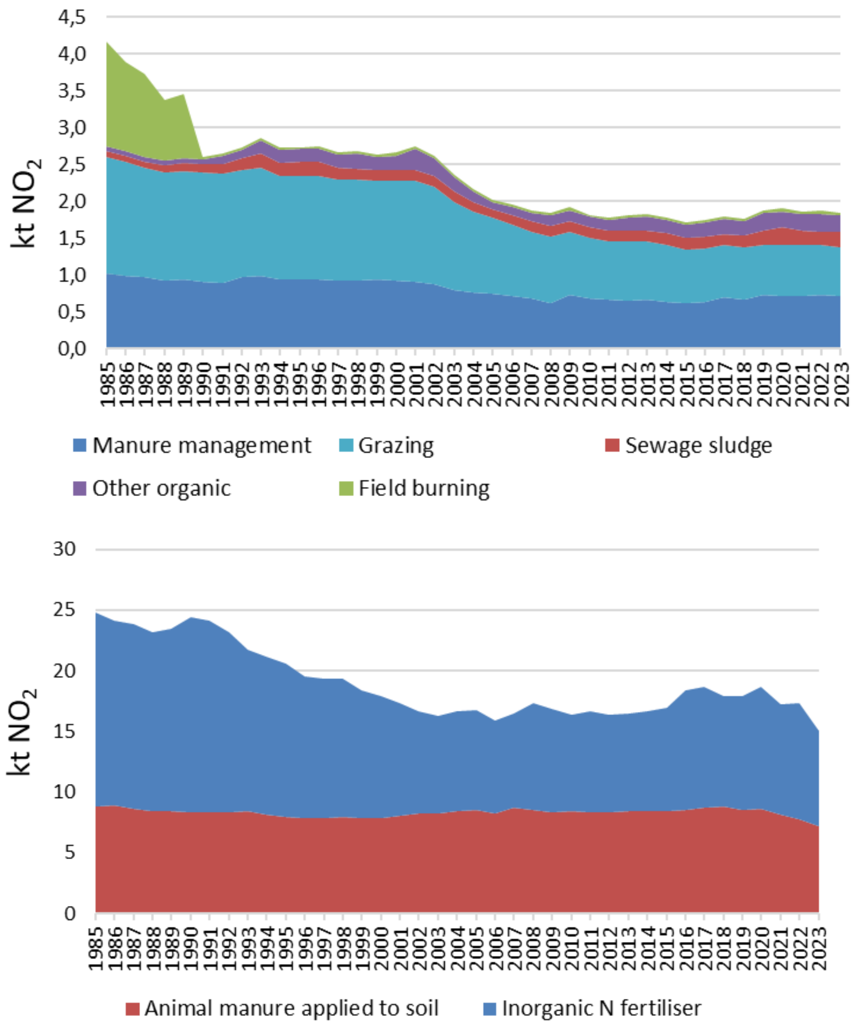

Figure 2.7 NO_2 emission for the agricultural sector, 1985-2023.

2.1.5 Other air pollutants

Other air pollutants include BC, CO, SO_2, heavy metals, dioxins, PAHs, PCBs and HCB. These are estimated from the field burning of agricultural residues and HCB also emits from use of pesticides. In 2023, BC, CO, SO_2, heavy metals, dioxin and PCB from field burning contributed up to 2 % to the total national emission, while HCB contributed with around 17 %. From 1989 to 1990, all emissions decreased significantly due to the banning of field burning.

2.2 Greenhouse gases

Table 2.3 shows the contribution of agricultural emissions to the national total in 2023. The agricultural emission contribution of N_2O, CH_4 and CO_2 is 88 %, 80 % and 1 %, respectively.

Table 2.3 Emission nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2) 2023, reported to UNFCCC, January 2025.

	N_2O	CH_4	CO_2
National total, kt	17	320	24 851
Agricultural total, kt	15	255	201
Agricultural part of national total, %	88	80	1

Table 2.4 shows the development in greenhouse gas emissions calculated in CO_2-eqv. The overall emission in 1985 is estimated to 15 276 kt, decreasing to 11 223 kt in 2023, corresponding to a 27 % reduction. Since 1990, the base year of the United Nations Framework Convention on Climate Change (UNFCCC) for CO_2, CH_4 and N_2O, the emission has been reduced by 23 %, mainly caused by a decrease in the N_2O emission.

Table 2.4 Development in the emission of greenhouse gases, 1985-2023, measured in kt CO_2 equivalents. For all years and distributed on main sources see Appendix C and D.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
CH_4	7 973	7 481	7 972	7 977	8 167	8 135	8 077	8 026	8 062	7 762	7 140
N_2O	6 575	6 500	5 749	5 232	4 887	4 666	4 648	4 683	4 315	4 266	3 881
CO_2	728	613	534	268	222	156	176	254	267	268	201
Agricultural total	15 276	14 594	14 254	13 477	13 276	12 957	12 901	12 964	12 644	12 296	11 223
National total	*	77 925	84 717	77 179	73 024	67 367	50 137	44 388	44 218	42 076	38 509
Agricultural part, %	*	19	17	17	18	19	26	29	29	29	29

* Greenhouse gases are reported for 1990-2023 and national total and agricultural part are therefore not shown for 1985.

2.2.1 CH_4

The CH_4 emission primarily originates from livestock digestive processes and manure management, while field burning of agricultural residues also is included as a source of emission but contributes less than 1 % to total agricultural CH_4 emissions.

The trend in CH_4 emissions from 1985 to 2023 is presented in Figure 2.8 and shows a reduction from 285 kt CH_4 in 1985 and from 267 kt CH_4 in 1990 to 255 kt CH_4 in 2023, corresponding to 10 % and 5 %, respectively. From 1985 to 2023, the emission from enteric fermentation decreased mainly due to a decrease in the number of cattle but because of a contemporary increase in feed intake for dairy cattle, the emission decreases less than the number of cattle. A contrasting development has taken place in emission from manure management, and this is mainly due to changes in animal barn and manure systems. From 2023 the farmers are obliged to frequently remove the slurry from the barns for fattening pigs (see Chapter 11), which is the main reason for the decrease in emissions observed in 2023.

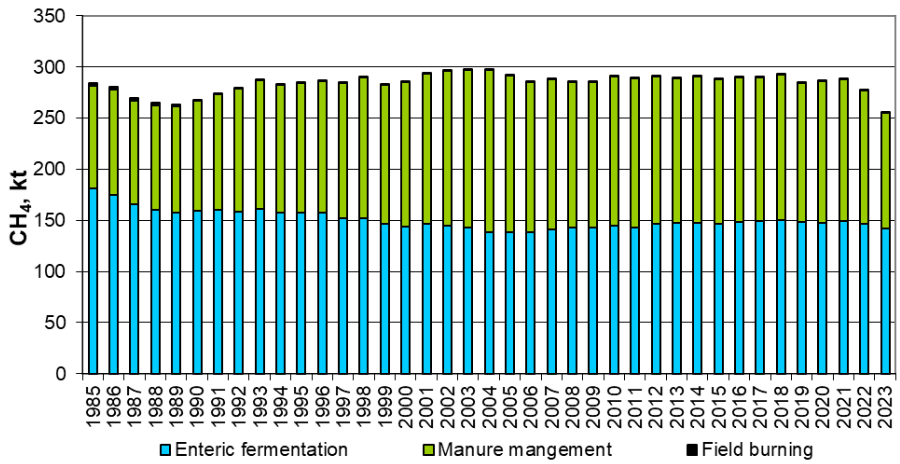

Figure 2.8 CH_4 emission 1985-2023, kt CH_4 per year.

2.2.2 N_2O

The emission of N_2O takes place in the chemical transformation of nitrogen and is therefore closely linked with the nitrogen cycle. There is a direct link between the estimation of the NH_3, NO_x and N_2 emission and the estimation of the N_2O emission.

Figure 2.9 presents the trend in the emissions of N_2O in the period 1985 to 2023 and reveals that the emission has decreased from 24.8 kt N_2O in 1985 and 24.5 kt N_2O in 1990 to 14.7 kt N_2O in 2023, which corresponds to a 41 % and 40 % reduction, respectively.

N_2O is produced from a range of different sources, which are presented in figure 2.9. The largest sources are animal manure (manure management and manure applied to soil) and inorganic N fertilisers applied to soil.

The part of the reduction is seen in the years 1985-2005 and is strongly related to a significant decrease in emissions from the use of inorganic N fertiliser and in nitrogen leaching and runoff. This development is primarily a consequence of an improved utilisation of nitrogen in animal manure and a lower use of inorganic fertiliser. From 2006-2020 is the N_2O emission almost unaltered but decrease further in 2021-2023, where reduction is seen from a range of sources.

Development in emission from animal manure is decreasing despite the increasing production of swine and poultry, the total amount of excreted nitrogen in manure has decreased from 1985 to 2023, which is due to an improved feed efficiency, especially for fattening pigs. A decrease in the total amount of nitrogen also means a decrease in N_2O emissions. Another reason for the reduction is the change from previous, more traditional, tethering systems with solid manure to slurry-based systems, because the N_2O emission is lower for liquid manure than for solid manure.

Another reason for the reduction in N_2O emissions over time, is the lower emission from cultivation of organic soils, because of a decrease in the cultivated area of organic soils.

The lower N_2O emission for crop residue in 2018 is a consequence of a very dry summer and thus much lower crop yield than a normal year, which result in a lower nitrogen content in crop residue.

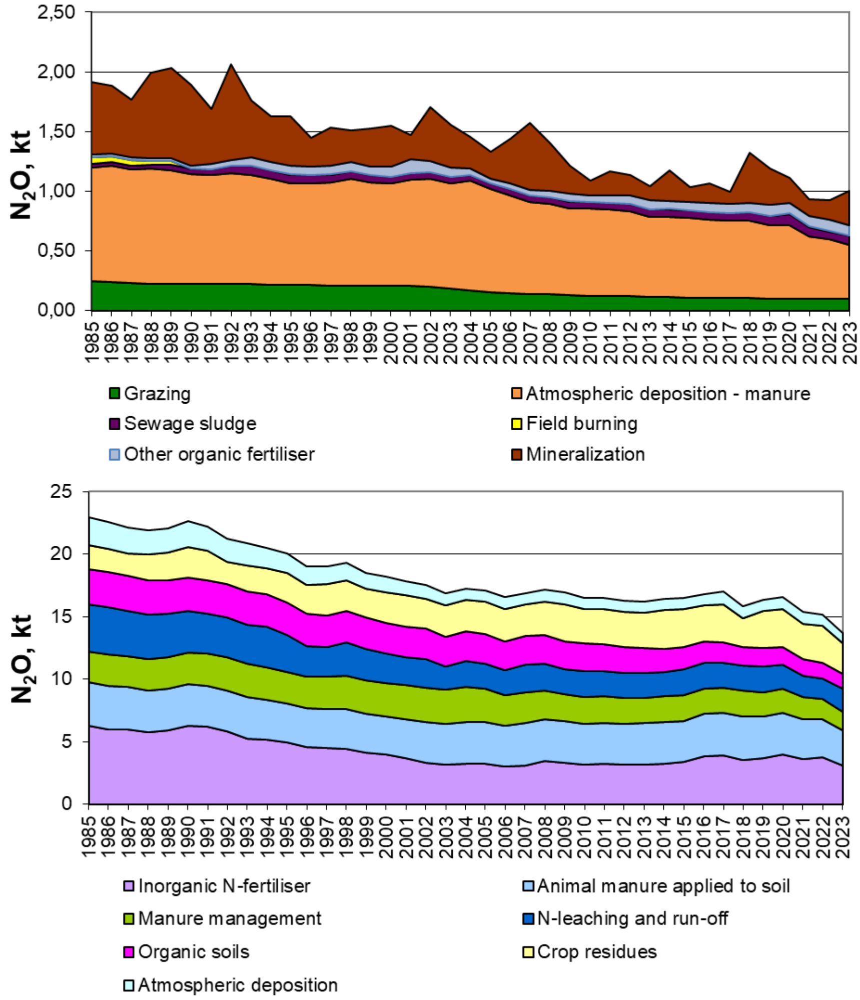

Figure 2.9 Emission of N_2O according to source, 1985-2023.

2.2.3 CO_2

Emission of CO_2 from agriculture originates from liming, urea application and use of other carbon containing fertilisers. The largest source is liming, which contributes with 91 % of the agricultural CO_2 emission in 2023. The emission has decreased from 1985 to 2023 from 728 kt CO_2 to 201 kt CO_2, which corresponds to a reduction of 72 %, mainly due to decrease in the use of lime.

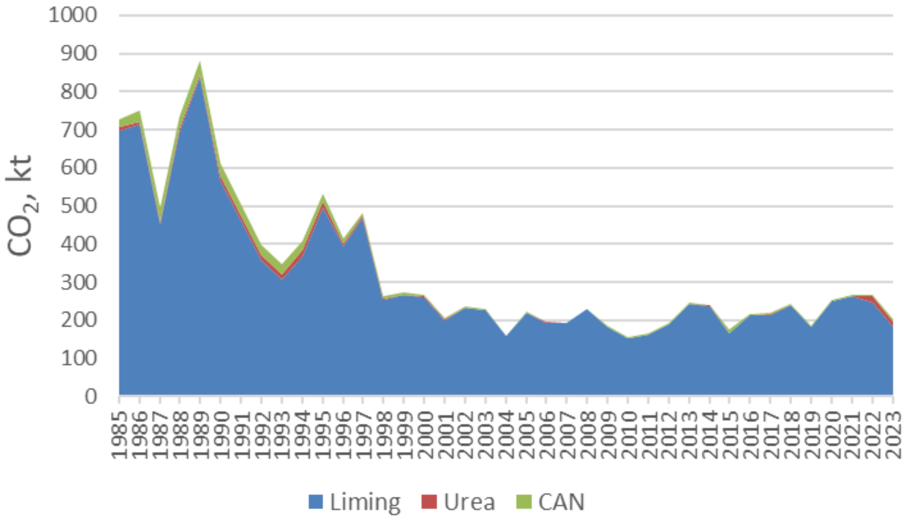

Figure 2.10 Emission of CO_2 from liming, urea and carbon containing fertilisers, 1985-2023.

3 Description of the model IDA

A comprehensive model complex called "Integrated Database model for Agricultural emissions" (IDA) is used to store input data and to calculate the agricultural emissions. The emission calculation includes all pollutants and all agricultural sectors.

3.1 Methodology

The main principle in the estimation of the emission is an activity (a) multiplied with an emission factor (EF) set for each activity (*i*). The overall emission is calculated as the sum of the emissions from all activities, see Equation 3.1.

$$E_{Total} = \sum a_i \cdot EF_i \qquad \text{(Eq. 3.1)}$$

Activity data for reporting in the agricultural sector could be, e.g. the number of cattle. The activity data for estimating emissions in the database are typically disaggregated into several different subcategories, which for cattle, for example, are dairy cattle, calves, heifers, bulls and suckling cows and again divided into different breeds and weight classes.

The emissions are estimated in accordance with international guidelines. The emission calculations for the greenhouse gases are in accordance with the methods in the IPCC Guidelines (IPCC, 2006 and IPCC, 2019). The calculation of air pollutant emissions is in accordance with the methodologies described in the EMEP/EEA Guidebook (EMEP, 2023). National values and methodological approaches are used where these better reflect the Danish agricultural conditions.

3.2 Data references – sources of information

Data input for emission calculations is collected, evaluated and discussed in collaboration with a range of different institutions involved in agricultural research and administration. The organisations include, for example, Statistics Denmark, DCA - Danish Centre for Food and Agriculture at Aarhus University, SEGES Innovation (agricultural advisory service) and a range of Danish Agencies.

Table 3.1 provides an overview of the various institutions and organisations who contribute with national data for the preparation of the agricultural emission inventories.

Table 3.1 Organisations contributing with input data to the preparation of the emission inventories for agriculture.

References	Link	Abbreviation	Data / information
Statistics Denmark – Agricultural Statistics	www.dst.dk	DSt	- livestock production - milk yield - slaughtering data - export of live animal - poultry, swine - agricultural area and distribution of crop types - crop yield
Danish Centre for Food and Agriculture, Aarhus University	http://dca.au.dk/	DCA	- N excretion - feed, amount and composition - animal growth - use of straw for bedding - N content in crops - modelling of data regarding N-leaching/runoff - NH_3 emission factor, barn, storage, application of manure - grazing days for cattle, sheep and goats
SEGES Innovation	https://segesinnovation.dk/	SEGES	- barn type (until 2004) - number of horses - grazing situation - manure application time and methods - estimation of extent of field burning of agricultural residue - acidification of slurry
Danish Environmental Protection Agency	www.mst.dk	DEPA	- sewage sludge used as fertiliser - industrial waste used as fertiliser (until 2004)
Agency for Green Transition and Aquatic Environment	https://sgav.dk/	SGAV	- farmers N accounts - barn type (from 2005) - industrial waste used as fertiliser (from 2005) - reduction factors for NH_3 reducing technology in barns - livestock production, sheep, goats, ostrich from CHR (central livestock register)
Danish Agency for Agriculture and Fisheries	https://lfst.dk/	LFST	- inorganic N fertiliser, consumption and types
The Danish Energy Agency	www.ens.dk	DEA	- amount of energy produced in biogas plants - used biomass in biogas plants

3.3 Integrated database model for agricultural emissions

The Integrated Database for Agricultural emissions (IDA) model complex is designed in a relational database system (MS Access). Input data are stored in tables in one database called IDA_Backend and the calculations are carried out as queries in another linked database called IDA.

Most emissions relate to livestock production, which is based on information on the number of animals, the distribution of animals according to barn type and, finally, information on feed consumption and excretion.

IDA operates with 42 different livestock categories, according to livestock type, weight class and age. These categories are subdivided into different barn types and manure types, which results in 300 different combinations of livestock subcategories and barn/manure types (Table 3.2). For each of these combinations, information on e.g. feed intake, digestibility, nitrogen excretion and emission factors are attached. The emission is calculated from each of these subcategories and then aggregated to the main livestock categories for reporting.

Table 3.2 Livestock categories and subcategories.

Main livestock categories	Subcategories	Number of subcategories divided into barn type and manure type system
Dairy cattle[1]	Dairy Cattle	40
Non-dairy cattle[1]	Calves (<½ yr), heifers, bulls, suckling cows	129
Sheep	Sheep and lambs	2
Goats	Including kids (meet, dairy and mohair)	3
Horses	<300 kg, 300-500 kg, 500-700 kg, >700 kg	4
Swine	Sows, weaners, fattening pigs	52
Poultry	Hens, pullets, broilers, turkeys, geese, ducks, ostriches, pheasants	61
Other	Mink, foxes, deer	9

[1] For all subcategories, large breeds and Jersey cattle are separately identified.

Data are collected from the organisations mentioned above (Table 3.1) and processed and prepared for import to the database. This step is done in spreadsheets. The data are imported and stored in the database called "IDA-backend" which also stores the emission factors for all pollutants. All emission calculations are done in IDA, which is linked to IDA-backend. This means that calculations of pollutants all use the same data on number of animals, crop area, amount of inorganic N fertiliser, etc. The calculated emissions and additional information are uploaded to the CRT and NFR templates via a conversion database. An overview of the data process is shown in Figure 3.1.

Data collection, processing and preparing

Data standards from EMEP/EEA and IPCC + data collected from:
- Statistics Denmark
- Danish Centre for Food and Agriculture
- SEGES Innovation
- Danish Environmental Protection Agency
- Agency for Green Transition and Aquatic Environment
- Danish Agency for Agriculture and Fisheries
- The Danish Energy Agency

↓

IDA-backend

Variables:	
Livestock	Number in each subcategory Barn type distribution N excretion Amount of straw Days on grass Amount of feed Amount of manure
Crops	Area
Inorganic fertiliser	Amount of N and of product
N leaching and run-off	Amount of N
Sewage sludge and industrial waste used as fertiliser	Amount of N
Crop residue	Amount of N
Organic soils	Area
Field burning of agricultural residues	Amount of burnt straw
Liming	Amount of lime
Pesticides	Amount of product
Mineralisation	Amount of N
All	Emission factors

↓

IDA

Emission calculations of:

- CH_4
- N_2O
- NH_3
- PM
- NMVOC
- CO
- CO_2
- NO_x
- SO_2
- Heavy metals
- PAHs
- Dioxins
- HCB
- PCBs
- BC

→

CRT and NFR templates

Output:

Emissions and additional information required in the template.

Figure 3.1 Overview of the data process for calculation of agricultural emissions.

4 Livestock population data

The livestock production is the main source of the agricultural emissions. To calculate the agricultural emission, a series of input data are used. Some values are obtained as default values from the IPPC guidelines and the EMEP/EEA Guidebook, while some are estimated based on national values, which closer reflect the Danish agricultural conditions. Table 4.1 lists the most important national variables and shows that some variables are used to calculate both NH_3 and greenhouse gas emissions. These variables (number of animals, distribution of barn types and estimated days on pasture and in barn) are described in this chapter. The remaining variables are included in the relevant pollutant chapters.

Table 4.1 Pollutants and variables.

Pollutants	National variables
NH_3, N_2O, CH_4	- No. of animals
NMVOC, NO_x, PM	- Barn type/manure type
	- Days in barn and on pasture
NH_3, N_2O	- N excretion (depends on feed intake)
NH_3, N_2O	- Conditions for storage and application of manure on agricultural soil
CH_4	- Feed intake (amount and composition)
	- Manure excretion (amount, content of dry matter and volatile solids)
	- Retention time and temperature for slurry in barn/storage
	- Amount of slurry to biogas production
NMVOC	Silage feeding

4.1 Livestock population

Livestock production figures are primarily based on the agricultural census from Statistics Denmark (DSt), see Appendix E for numbers of livestock 1985-2023 given in annual average population (AAP) – definition on AAP are given in the EMEP/EEA Guidebook (EMEP, 2023).

Only farms larger than five hectares are included in the annual census from Statistics Denmark. Especially horses, goats and sheep are placed on small farms, which means that the number of animals given in the Agricultural Statistics properly underestimate the actual animal population. Therefore, the numbers of sheep and goats are based on the Central Husbandry Register (CHR), which is the central register of farms and animals managed by the Danish Agricultural and Fisheries Agency. From 2010, the annual census includes farms with more than 20 goats and sheep, but the CHR is considered as more reliable because the register includes all animals regardless of farm size. In statistics from Statistics Denmark are number of sheep in 2023 around 153 000, while in CHR are the number around 186 000. Number of goats cannot be collected from Statistics Denmark. The number of horses is based on data from SEGES (Holm, 2024) which is 180 000 in 2023, where Statistics Denmark only have around 45 000 in the statistics.

The inventories furthermore include emissions from deer, ostrich and pheasants, but these animal categories are not included in Statistics Denmark. Data on the number of deer and ostrich are based on the CHR, while the number for pheasants is based on expert judgement by the pheasant breeding association (Stenkjær, 2009, Pers. Comm.).

4.1.1 The Danish Normative Standards

The DCA – Danish Centre for Food and Agriculture provides Danish standards related to feed consumption, excreted volumes, nutrient content of nitrogen, phosphor and potassium, dry matter in manure and contribution of different manure type. These standards are all a part of the "Danish Manure Normative Standards", which is used for fertiliser planning and control by the Danish farmers and authorities (Børsting et al., 2021, Børsting & Hellwing, 2024). The complexity and dynamics of the system has increased over the years to ensure the development of accurate values. Furthermore, the normative standards include emission factors for NH_3, which are based on a combination of measurements and model calculations.

The Danish Manure Normative Standards are based on annually updated data from a large number of farms and thus reflects the actual Danish agricultural production conditions. DCA receive data from SEGES, which is an independent organisation related to the Danish agricultural advisory service. SEGES carries out a considerable amount of research and development activities, as well as running databases collecting data from the Danish farmers for dairy production, beef production, swine production and poultry production to be used for benchmarking between farmers with similar livestock productions. Data used to calculate the manure normative values from these databases covers production (milk yield, weened piglets per litter, growth rate), feed intake, feed efficiency, and feed composition. The data from dairy herds represents more than 50 % of all herds, and a higher proportion of all dairy cows. For slaughter calves, data represented about 60 % of the slaughtered animals. The swine values were based on 700 000 sows equivalent to 70 % of all sows, and the data from fattening pigs were based on 8.7 million pigs equivalent to about 60 % of all pigs slaughtered in Denmark (Børsting, 2024). For poultry, 80-90 % of the production and approximately 100 % of the fur production were covered. The data have high reliability, because it is the actual data which the farmers are dependent on in their daily management. With the very large proportion of the cattle, swine and poultry farms reporting data to the database, these data are considered to be representative for Danish animal production.

Previously, the normative standards were updated and published every third or fourth year (Laursen, 1987; Laursen, 1994; Poulsen and Kristensen, 1997). From 2001, these standards are updated annually and available to download at the homepage of DCA:
http://anis.au.dk/forskning/sektioner/husdyrernaering-og-fysiologi/normtal/ (July 2025). One of the reports concerning the normative standards is published in English in Poulsen and Kristensen (1998) and is available at the homepage of DCA, see list of references.

The normative standards for feed intake and N excretion are for some livestock categories, e.g. dairy cattle, heifers (2003-2023) and sows, given for a year animal, which means the average number of animals, present within the year. This corresponds to the definition of annual average population (AAP) in the EMEP/EEA Guidebook (EMEP, 2023). For other livestock categories such as heifers (1985-2002), bull calves, bulls, weaners, fattening pigs and pullets, the normative standards are given per animal produced.

Below follows a description of how the livestock production is calculated for each animal category.

4.1.2 Cattle

Cattle are divided into six main categories dairy cattle, bull calves, heifer calves, bulls more than 6 months destined for slaughter, heifers more than 6 months to be used for breeding purposes, and suckling cows. For all categories except for suckling cows, a distinction is made between large breeds and Jersey cattle (Table 4.2). Suckling cows are divided into three groups, based on weight. The categories are further divided into different barn systems and manure types.

Data regarding the distinction between large breed and Jersey cattle were, until 2000, collected via special calculations from Statistics Denmark. From 2001, the share of Jersey cattle has been provided by SEGES and are based on registrations from annual yield controls covering approximately 90 % of dairy cattle.

Table 4.2 Proportion of Jersey cattle, %[1].

Main categories of cattle	2001	2005	2010	2015	2020	2023
Dairy cattle	12.2	12.5	13.1	14.4	14.5	15.3
Heifer calves, 0 - 6 months	9.4	9.4	10.1	10.6	12.5	12.5
Heifers, 6 months to calving	8.5	8.6	9.3	9.4	11.0	12.1
Bull calves, 0-6 months	4.2	4.0	2.7	2.2	1.7	1.8
Bulls, 6 months to slaughter age	6.6	6.2	3.8	3.6	3.0	2.7
Suckling cows	Weight; <400 kg, 400-600 kg and >600 kg					

[1] Source: Nielsen (2024, Pers. Comm.).

To calculate the emission, the number of animals has to be quantified for each of the categories.

Dairy cattle

The annual average population of dairy cattle is based on Statistics Denmark.

Heifers

The number of heifers is calculated by two different methodologies, which is due to a change in the Danish Normative Standards in 2003. This change in the calculation has no impact on emissions.

From 1985 to 2002, the normative standards for N excretion are given per animal produced, which is described in Mikkelsen et al. (2006). From 2003 and onwards the normative standards are changed so the values of feed intake and N excretion represent AAP (annual average population), which are based on the number of animals reported by Statistics Denmark.

From 2003, the number of heifers per year is calculated as:

$$No._L = No._{DSt} \cdot (1 - J) \qquad \text{(Eq. 4.1a)}$$

$$No._J = No._{DSt} \cdot J \qquad \text{(Eq. 4.1b)}$$

Example for 2023 heifer calves (< ½ year):

$$No._L = 167\ 066 \cdot (1 - 0.125) = 146\ 183$$

where:

$No._{DSt}$	= number of heifers <½ year given by Statistics Denmark
$No._{L}$	= number of large breed heifers <½ year
$No._{J}$	= fraction of Jersey heifers <½ year
J	= fraction of Jersey heifers

Bulls

The normative standards from DCA represent feed intake and N excretion per animal produced, therefore the emission calculation has been based on the number of animals produced.

The production of both bulls and bull calves is based on data on slaughter provided by Statistics Denmark. Animals discarded during the slaughtering process is taken into account.

Number of total bulls and bull calves produced

For the calculation of bulls > 6 months is the number of slaughtered young bulls, bulls, steers and discard cattle given by Statistics Denmark.

Number of bulls produced per year:

$$No._{bulls} = No._{vb} + No._{b} + No._{s} + No._{dis} \qquad \text{(Eq. 4.2)}$$

where:

$No._{bulls}$	= number of bulls
$No._{y\,b}$	= number of slaughtered young bulls
$No._{b}$	= number of slaughtered bulls
$No._{s}$	= number of slaughtered steers
$No._{dis}$	= number of discarded cattle

Number of bull calves < 6 months is calculated based on the number of bulls and number of veal calves given by Statistics Denmark:

$$No._{bullcalves} = No._{bulls} + No._{vc} \qquad \text{(Eq. 4.3)}$$

where:

$No._{bull\ calves}$	= number of bull calves
$No._{bulls}$	= number of bulls
$No._{v\,c}$	= number of veal calves

Example from 2023:

$$No._{bulls} = 36\ 400 + 132\ 800 + 8\ 100 + 1\ 385 = 178\ 685$$

$$No._{bull\ calves} = 178\ 685 + 5\ 900 = 184\ 585$$

Distribution between large breed and Jersey

An average slaughter weight for large breed cattle and Jersey cattle of 410 kg and 328 kg, respectively, is assumed in the normative standards (Børsting & Hellwing, 2024).

The number of bulls from suckling cows is counted under the category of bull calves, large breed. It is assumed that the allocation between dairy cattle and suckling cows is approximately the same for bull and for bull calves. The fraction of suckling cows is 11.0 % in 2023 (DSt, 2024).

The number of bulls/bull calves from suckling cows is estimated. For the remaining part of cattle, the distribution between large breed and Jersey is estimated by using the percentage for Jersey cattle given in Table 4.2.

Equation 4.4:

$$Frac = No._{S,DSt}/(No._{D,DSt} + No._{S,DSt}) \quad \text{(Eq. 4.4)}$$

where:

Frac	= fraction of suckling cows
$No._{S,\,DSt}$	= number of suckling cows given by Statistics Denmark
$No._{D,\,DSt}$	= number of dairy cattle given by Statistics Denmark

The number of respectively large breed, Jersey bulls and bull calves produced is calculated as follows:

Equation 4.5 a) and b):

$$No._{B,L} = (No._B - No._B \cdot Frac) \cdot (1 - J) + (No._B \cdot Frac) \quad \text{(Eq. 4.5a)}$$

$$No._{B,J} = (No._B - No._B \cdot Frac) \cdot J \quad \text{(Eq. 4.5b)}$$

where:

$No._{B,\,L}$	= number of bulls produced, large breed
$No._{B}$	= number of bulls produced
$No._{B,\,J}$	= number of breed bulls produced, Jersey
Frac	= fraction of suckling cows
J	= % of Jersey bulls

Calculation example for 2023:

Table 4.3 Number of bulls, 2023.

	No. of animals	No. of animals produced	Fraction of suckling cattle	No. of bulls produced	
				Large breed	Jersey
Bull calves < ½ year	102 310	184 585	0.110	181 629	2 956
Bulls > ½ year	107 363	178 685	0.110	174 393	4 292

Suckling cows

The number for suckling cows is provided by Statistics Denmark. In the farmer accounts, where the farmer registrates the number of animals per barn type, are suckling cows divided into three groups by weight and this distribution between weight intervals are used to divide total number of suckling cows in weight intervals.

4.1.3 Swine

There are six different main swine categories: conventional sows (including piglets up to 6.4 kg), conventional weaners (6.4 to 31 kg), conventional fattening pigs (31 to 115 kg), organic sows (including piglets up to 15 kg), organic weaners (15 to 31 kg) and organic fattening pigs (31 to 113 kg). The production of swine is divided into conventional and organic produced animals because the production system for organic farmed swine differs significantly from the conventional production. The share of organic farmed swine is estimated by numbers from the farmer accounts, where the farmer registrate number of animals per barn type. In the farmer accounts are barn types for conventional farmed swine and organic farmed swine, respectively.

Sows

The number of sows is provided by Statistics Denmark. Sows include pregnant sows, suckling sows and barren sows.

Weaners and fattening pigs

The normative standards for feed intake and N excretion for fattening pigs and weaners are provided per pig produced; therefore, the emission calculation has been based on the number of animals produced.

The production of both weaners and fattening pigs is based on data on slaughter provided by Statistics Denmark. Discarded animals during the slaughtering process and export of live animals are taken into account. The calculated emission from weaners and fattening pigs also includes the emission related to breeding of boars and slaughtered and discarded sows (L&F, 2024).

The number of fattening pigs is based on the total meat production divided with an average slaughter weight based on the normative standards, which in 2023 was reported as 88 kg (Børsting & Hellwing, 2024).

Number of fattening pigs produced:

$$No. = \left(\frac{AM}{AS}\right) + S_b + Ex \qquad \text{(Eq. 4.6)}$$

where:

No.	= number of fattening pigs
AM	= amount of meat produced (including discarded animals during the slaughtering process), kg
AS	= average slaughter weight, kg
S_b	= slaughtered animals from breeding production (including discarded sows), number
Ex	= export of live fattening pigs and animals for breeding, number

Example from 2023:

$$No._{fattening} = \left(\frac{1\ 278\ M\ kg}{88\ kg}\right) + 516\ 700 + 297\ 300 = 15\ 332\ 000 \cong 15.3\ million$$

The number of weaners is calculated as the number of fattening pigs plus the number of exported live weaners, which has increased significantly in the last 25 years from 1.1 million in 2000 to 14.6 million in 2023.

Number of weaners produced:

$$No. = No._{fattening} + No._{exported} \qquad \text{(Eq. 4.7)}$$

where:

No.	= number of weaners, weight 6.4-31 kg
$No._{fattening}$	= total number of produced fattening pigs
$No._{exported}$	= number of exported living weaners

Example for 2023:

$$No._{weaners} = 15.3\ million + 14.6\ million = 29.9\ million$$

The normative standards for feed intake and excretion values for fattening pigs are in 2023 based on a 115 kg live weight, equivalent to 88 kg slaughter weight (Børsting & Hellwing, 2024). Slaughtering data are as mentioned based on Statistics Denmark, including discarded animals during the slaughtering process. Information on discarded sows is based on information from SEGES and for 2023 the share of discarded sows is 16.5 % (SEGES, 2024). Table 4.4 shows the background data for 2023 used for estimation of number of fattening pigs and weaners.

Table 4.4 Background data for estimating number of produced fattening pigs and weaners, 2023.

Fattening pigs to slaughter (million kg meat)	
Delivered to slaughterhouse[a]	1 274
Slaughtered for the producer at slaughterhouse[a]	0
Slaughtered at home[a]	0.2
Discarded at slaughterhouse[b]	3
Meat production from fattening pigs, million kg meat	1 278
Slaughtered animals from breeding production (1000 unit)	
Gilt to slaughter[a]	6
Sows[a]	356
Boars[a]	4
Discarded sows[c]	150
Total number slaughtered from breeding, (1 000 unit)	517
Export of living animals (1 000 unit)	
Fattening pigs and animals for breeding[d]	297
Weaners[e]	14 568
No. of produced animal (1 000 unit)	
No. of produced fattening pigs	15 332
No. of produced weaners	29 900

[a]Data from Statistics Denmark (DSt, 2024 – Table ANI5).
[b]Calculated as number of discarded swine divided by average slaughter weight. Both values from Statistics Denmark (DSt, 2024 – Table ANI5).
[c]Calculated as number of sows (DSt, 2024 – Table HDYR1) multiplied with share of discarded sows (SEGES, 2024).
[d]Calculated as total number of exported swine (DSt, 2024 – Table ANI5) minus number of exported weaners.
[e]Calculated as share of weaners of total number of exported swine (DSt, 2024 – Table ANI5). In 2023 this share was 98 %.

Table 4.5 shows the number of swine other than sows reported by Statistics Denmark, compared to the calculated number of weaners and fattening pigs produced per year. The number of animals given by Statistics Denmark represents the number given in AAP, while the emission calculations are based on number of produced swine. Comparing AAP and produced numbers show a production cycle in 2023 of 3.5 and 5.4 for fattening pigs and weaners, respectively, which are reasonable.

Table 4.5 Number of weaners and fattening pigs, 2023.

	No. of animal, Statistics Denmark, 1 000 unit	No. of produced swine, 1 000 unit	Production cycle
Swine (other than sows)	9 912		
Fattening pigs (31-115 kg)	4 344	15 322	3.53
Weaners (6.4-31 kg)	5 568	29 900	5.37

4.1.4 Poultry

For poultry, there are four main categories: laying hens, broilers, turkeys and other poultry (geese, ducks, pheasants and ostrich).

Laying hens

The category of laying hens includes hens and pullets. The normative standards for hens are based on average annual hens (units of 100) and include the feed, bedding, N excretion etc. used for the cocks there is a part of the production of hens. Six main production forms for hens are distinguished between – free-range, organic, barn, battery, aviary as well as production of hens for brooding. The distribution between the different production forms is based on data from Statistics Denmark, see Table 4.6.

Hens

The number of laying hens is based on the egg production. The production of eggs divided on production forms are given by Statistics Denmark (DSt, 2024 – Table ANI8) and the production of eggs per hen is given in the normative standards (Børsting & Hellwing, 2024). The number of hens within each category is calculated as follows:

$$No._i = \frac{(a_i + a_h \cdot P_i/100) \cdot 1000\ 000}{Y_i} \quad \text{(Eq. 4.8)}$$

where:

$No._i$ = number of hens within the production form i

a_i = eggs produced for sale in the production form i, in million kg (DSt, 2024 – Table ANI8)

a_h = eggs produced for home sale, in million kg (DSt, 2024 – Table ANI8)

P_i = share of the production form i, %

Y_i = production of eggs per hen per year within the production form i, in kg (Børsting & Hellwing, 2024)

Below is an example of calculation of the number of free-range hens in 2023 (100 unit):

$$no_{free-range} = \frac{(6 + 12 \cdot 8.3/100) \cdot 1000\ 000}{19.7} / 100 = 3\ 553$$

Calculations of number of hens for breeding do not include eggs produced for home sale.

The category of battery hens is furthermore divided into three different barn systems according to the differences in the handling of manure. These categories are termed manure houses, manure tanks and manure cellar.

Table 4.6 Distribution of hens in different categories in 2023, 100 unit.

	No of hens, 100 unit	%, distribution on production forms	No. of hens, 100 unit
Hens – total	50 539		
- of which egg layers for brooding	7 857		7 857
- of which egg layers*	42 681		
Free-range		8.3	3 553
Organic		30.6	13 438
Barn		50.0	21 000
Battery, manure house		11.1	4 676
Battery, manure tank		0.03	14
Battery, manure cellar		0	0
Aviary		0	0

* Including eggs produced for home sale.

Pullets

The normative standard for pullets is based on the production of 100 pullets. The production time for pullets is 119 days (Børsting & Hellwing, 2024) which corresponds to approximately 3.1 production cycles during the year (365/119 = 3.1). Annual production is determined using the population figure provided by Statistics Denmark (DSt 2024 – Table HDYR1) (chicken for breeding) multiplied by the number of production cycles.

From the 2026 submission the number of cleaning days will be included in the calculation of produced pullets. So, from the 2026 submission, the production time for pullets will be 119 days plus 28 cleaning days (Kai, 2025) corresponding to approximately 2.5 production cycles during the year (365/(119+28) = 2.5).

The total number of pullets produced per year is divided into three main production forms – consumption (net), consumption (floor) and pullets used for brooding eggs. The multiplication factor related to the percentage distribution of the three different production forms is from 1985 to 2004 based on information from the Danish Agriculture & Food Council (Jensen, 2008, Pers. Comm.) and from 2005 based on information from SGAV – see Table 4.7.

Calculation of the total number of pullets produced per year

$$No._{pu} = no_{DSt} \cdot \frac{365}{(T+E)} \cdot (\frac{P}{100}) \quad \text{(Eq. 4.9)}$$

where:

$No._{pu}$	= number of pullets within a given production form
$No._{DSt}$	= number of pullets given by Statistics Denmark
T	= production time, days
E	= cleaning days, days
P	= % distribution of the production form

Below is, as an example, the calculation of the number of pullets produced for consumption, floor production (100 unit), for 2023:

$$No._{pu} = 16\ 068 \cdot \frac{365}{(119+28)} \cdot \left(\frac{61.8}{100}\right) = 24\ 656$$

Table 4.7 Calculation of the number of pullets produced in 2023,100 unit.

	No. of pullets given in DSt* 100 unit	Distribution on production forms	Production time	Cleaning days	Production runs per year	No. of pullets produced per year 100 unit
		%	days	days		
Pullets - total (population*)	16 068	100				
Consumption, floor		62	119	28	2.5	24 656
Consumption, net		9	119	28	2.5	5 571
Egg brooding, floor		29	119	28	2.5	4 025
Number of pullets produced						34 252

* Statistics Denmark

Broilers, turkeys, ducks and geese

Numbers of broilers, turkeys, ducks and geese are based on the number of animals produced. The calculation of production is based on slaughter data from Statistics Denmark (DSt 2024 – Table ANI6). Export of live animals (Larsen, 2024 (DSt)) and farmers' private consumption of animals (DSt 2024 – Table ANI6) are also taken into account.

Calculation method to estimate poultry production:

$$No._{po} = No._{DS} + No._{PC} + No._{E} \qquad \text{(Eq. 4.10)}$$

where:

$No._{po}$ = number of the given category of poultry (broilers, ducks, geese or turkeys)
$No._{DS}$ = number of animals delivered to slaughter
$No._{PC}$ = number of animals slaughtered at home for private consumption
$No._{E}$ = number of live animals exported

Example for the number of broilers produced in 2023 (in 1 000 unit):

$$No._{po} = 102\,736 + 500 + 14\,919 = 118\,155$$

The calculated number of broilers, turkeys, ducks and geese produced is compared in Table 4.8 with the figures for the number of AAP reported by Statistics Denmark (DSt 2024 – Table HDYR1). The number of average annual animals represents the number of barn places. Comparing AAP and produced numbers show the production cycle in 2023 given in Table 4.8, which are reasonable.

Table 4.8 Number of broilers, turkeys, ducks and geese, 2023.

	No. of animal, Statistics Denmark, 1 000 unit	No. of produced animals 1 000 unit	Production cycle
Broilers	15 652	118 154	7.55
Turkeys	251	481	1.92
Ducks	65	91	1.40
Geese	3	13	3.71

Pheasants and ostriches

Statistics Denmark has no data on the number of pheasants and ostriches produced. The number of pheasants is based on expert judgement by the pheasant breeding association (Stenkjær, 2009, Pers. Comm.) and is estimated at 1

062 500 in each of the years 1985-2023. Pheasants are bred for hunting, and this is estimated as unaltered in the period. The number of ostriches is based on information obtained from the Central Husbandry Register (CHR), which is the central register for farm data of LFST (Danish Agricultural and Fisheries Agency), see Table 4.9. The production of ostrich in Denmark started in 1993 and no production of ostrich has taken place before 1993.

Table 4.9 Number of ostriches 1985 to 2023.

	1985	1995	2000	2005	2010	2015	2020	2021	2022	2023
Ostrich	0	3 333	8 889	3 661	358	91	91	88	82	111

4.1.5 Horses

The number of horses is split into four different weight classes: small ponies up to 300 kg, lighter breeds – 300-500 kg, medium-weight breeds – 500-700 kg and heavy breeds – more than 700 kg.

The figures from Statistics Denmark only includes horses on farms larger than 5 ha. However, a study of pets undertaken by Statistics Denmark (DSt, 2000) has indicated that a significant number of horses are found on smaller hobby farms and riding schools that are below 5 ha. The total number of horses in the inventory is based on the horse breeding register managed by SEGES and here is also information about the distribution in weight classes. In 2023, the distribution is 15 %, 20 %, 63 % and 2 % for 300 kg, 300-500 kg, 500-700 kg and more than 700 kg, respectively.

In 2023, 45 382 horses were listed by Statistics Denmark (DSt 2024 – Table HDYR1), as opposed to 180 000 according to SEGES (Holm, 2024). SEGES has estimated the number of horses in 2000 to 150 000 and in 2008 to 190 000. The numbers in between are interpolated. The number of horses before 2000 is based on information from SEGES and the Danish Agriculture & Food Council. Number of horses from 2009 to 2018 is based on a new judgement from SEGES, which shows a decrease in number of horses until 2014 and then increase to 2023. Table 4.10 shows the number of horses registered by Statistics Denmark and SEGES.

Table 4.10 Number of horses 1985 to 2023 (1 000 unit).

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Statistics Denmark[1]	32	38	18	40	54	60	58	43	43	46	45
SEGES[2]	140	135	143	150	175	165	155	183	183	183	180

[1] Agricultural units > 5 ha.

[2] Total number of horses incl. horses on small farms and riding schools.

4.1.6 Sheep, goats and deer

The normative standards for goats are based on average annual breeding goats including kids, because this corresponds to the unit in the normative standards. For sheep normative standards are provided for both sheep and lambs. For both sheep and goats, the normative standards include the feed, bedding, N excretion etc. used for the male animals there is a part of the production. It is expected that a share of the sheep is to be found on farms below 5 ha and thus the actual number is higher than reported by Statistics Denmark. No numbers for goats are given in Statistics Denmark. Therefore, data on the number of sheep and goats are based on the Central Husbandry Register (CHR). For the years 1985-1996 the number of mother sheep are based on numbers from Statistics Denmark but multiplied by 1.2 because it is estimated (based on expert judgement) that the number are 20 % higher than reported in the statistics.

The number of sheep has been divided into number of mother sheep and lambs. Number of mother sheep is based on numbers from CHR, while the number of lambs is the number of mother sheep multiplied by 1.5, because sheep on average give birth to 1.5 lambs per year.

Table 4.11 Number of mother sheep 1985-2023 (1 000 unit).

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Statistics Denmark[1]	33	77	67	68	79	72	65	60	57	78	66
CHR[2]	40	92	81	112	126	111	84	80	78	76	75

[1] Agricultural units > 5 ha.

[2] 1985-1996 numbers from Statistics Denmark multiplied by 1.2.

The production of deer is included in the Danish inventories and covers animals bred for meat on farms (in enclosures) and not deer in the wild. No data on the number of deer are available from Statistics Denmark; thus the number of deer is based on CHR.

4.1.7 Fur animals

The production of fur animals is calculated as the population of mink, fitchew, foxes and Finn racoon as reported by Statistics Denmark, where the main part of the animals is mink. From 2012 the number of fur animals from Statistics Denmark only includes mink, because the production of the other mentioned fur animal types is considered negligible. In 2020 during the COVID-19 pandemic all mink in Denmark were culled to prevent spreading of the disease. In 2023, the production slowly started up again.

4.2 Barn systems

For each livestock category, the number of animals is divided into a range of different barn systems. The barn system is a determining factor for how the animal manure is handled and therefore decisive for the distribution into liquid and solid manure systems.

No systematic record of the distribution of the different barn types exists until 2004. Therefore, the distribution from 1985 to 2004 is based on expert judgement. For cattle and swine, the distribution is based on information from Rasmussen (2003, Pers. Comm.) and Lundgaard (2003, Pers. Comm.). The distribution of barn systems for fur animals is obtained from Risager (2003, Pers. Comm.). The barn distribution for poultry is determined based on efficiency controls by the Danish Agriculture & Food Council (Jensen, 2008, Pers. Comm.). From 2005 onwards, the distribution of the different barn types is based on information from SGAV - Agency for Green Transition and Aquatic Environment from the farm nitrogen budgets, which farmers must submit annually.

Appendix F presents the distribution of the different barn types for all livestock categories and in Appendix G are shown the Danish barn types and the associated IPCC manure management systems (MMS). Table 4.12 and Table 4.13 show the estimated distribution of barn types from 1985 to 2023 for dairy cattle and fattening pigs, the two most important livestock categories.

The structural development in the agricultural sector has influenced the change in barn types. New barn facilities have been built and for dairy cattle, most of the tethered barns have been replaced by larger loose-barn facilities. In 1985, 85 % of the dairy cattle were kept in tethered stalls and in 2023, this had been reduced to 2 %. In the case of fattening pigs, many solid floor systems have been replaced by a system with slatted floors. The consequence of this development is that more of the animal manure is handled as slurry. For fattening pigs and weaners has fully slatted floor been banned after 2015 and was replaced with partly slatted floor by filling in the space between the slats in some of the area of the pigsties.

Table 4.12 Dairy cattle distributed on main barn types, %.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Tethered barn	85	79	73	46	20	12	7	3	3	3	2
Loose-barn with beds	14	18	21	43	70	82	87	89	88	88	88
Deep litter	1	3	6	11	10	6	6	8	9	9	10

Table 4.13 Fattening pigs distributed on main barn types, %.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Fully slatted floor	29	51	60	58	53	54	40	0	0	0	0
Partly slatted floor	30	23	24	31	38	41	58	99	99	99	99
Solid floor	40	22	11	5	3	2	1	0	0	0	0
Deep litter	1	4	5	6	6	3	1	1	1	1	1

4.3 Number of days in barn and on pasture

A proportion of the manure from dairy cattle, heifers, suckling cows, sheep, goats, horses and deer is deposited on the field during grazing. The share of the manure dropped outside is converted to number of days. E.g. if 15 % of the manure is dropped outside the number of grazing days are calculated as 365*0.15 = 55 days. For cattle production, the estimated days on grass are a weighted value between conventional and organic production. Organic production of cattle has a minimum number of days the animals must be outdoors.

For swine, deer, geese and pheasants, the time spend outside the barn is defined as a barn type, while for hens and ostriches time spend outside are defined as a manure type, which mean emissions from “grazing” are calculated for the manure type instead of calculated as days on grass. So grazing days for these barn/manure types are set to 365 days.

Number of days the animals are on grass are defined as days the animals are outside the barns, also called actual days on grass. For heifers, suckling cows, sheep, and goats the feed intake (intake of N) is higher during grazing compared to the period in barn, this is called feeding days on grass. Feeding days on grass is a conversion of this higher feed intake on grass.

In the calculation of NH_3, NO_x and N_2O emission, feeding days on grass are used, while actual days on grass are used for the emission calculation of PM and NMVOC. In the calculation of CH_4 from enteric fermentation, feeding days on grass are used, while for CH_4 from manure management both feeding and actual days on grass are used, see Chapter 11.

The number of estimated grazing days is based on information from SEGES (Martinussen, 2022) and normative standards (Børsting et al., 2021).

The number of grazing days for dairy cattle and heifers decreased in the period 2002-2023 due to the structural development towards larger farms, with lower proportion of grazing (See Appendix H). For productions with a large number of cattle managing grazing becomes logistically more complex, especially moving cows to and from distant fields and milking. Furthermore, feeding indoors with an optimized complete feed mixture, which ensures a more consistent and high milk yield, are more effective compared to grazing, where the quality and quantity of grass can vary. Contemporaries are the development in barn types towards barns that are designed for cows to stay indoors permanently.

Table 4.14 Number of grazing days corresponding to the proportion of N in manure deposited on the field during grazing, 2023 (Martinussen, 2022, Børsting et al., 2021).

Livestock category		2023
Cattle:		
Dairy cattle		20
Heifer > ½ year*	Feeding days on grass	56
	Actual days on grass	47
Suckling cows*	Feeding days on grass	224
	Actual days on grass	184
Calves and Bulls		0
Swine:		
Sows, weaners and fattening pigs		0
Sows, outdoor	Only farrow period	365
Organic sows		195
Poultry:		
Pullets, broilers, turkeys and ducks		0
Hens and organic broilers	Share of manure set outside	10%
Ostrich	Share of manure set outside	20%
Geese and pheasant		365
Other:		
Sheep and goats (meat and milk)*	Feeding days on grass	265
	Actual days on grass	215
Mohair goat*	Feeding days on grass	265
	Actual days on grass	203
Horses		182,5
Deer		365
Fur animals		0

* Actual days on grass are the number of days that animals are outside. Feeding days on grass is higher than actual days on grass, due to a higher feed intake (intake of N) and N excretion during grazing compared to the period in housing. Feeding days on grass is a conversion of this higher feed intake/N excretion on grass.

5 Ammonia

Figure 5.1 shows the NH_3 emissions from different sources in 2023. The emission from manure management contributes 39 % and manure applied to soils 25 % of the total NH_3 emission from the agricultural sector. The emissions from cultivated crops and inorganic N fertilisers contribute 10 % and 18 %, respectively. The remainder comes from grazing animals (4 %), crop residues (2 %) and the last 2 % is from other sources such as sewage sludge and other organic fertiliser applied to agricultural land, field burning of agricultural residues and ammonia treated straw. Description of trend 1985 – 2023 see also Chapter 2.1.1. Appendix A shows the NH_3 emissions from all sources for the period 1985 – 2023.

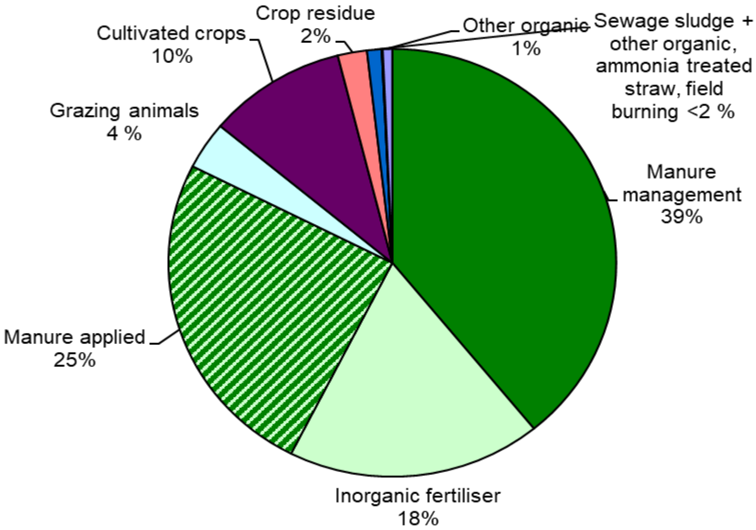

Figure 5.1 NH_3 emissions distributed on sources, 2023.

5.1 Animal manure

5.1.1 Total N and TAN

The emission of NH_3 from manure management is calculated on the basis on nitrogen excreted from livestock. Most of the N excreted that is readily degradable and broken down to NH_4-N is found in the urine. Previously, the emission calculation was based on the total N content in manure for all manure types. However, the relationship between NH_4-N and total N will not remain constant over time due to changes in feed composition and feed use efficiency.

To be able to implement the effect of NH_3 reducing measures such as changes in feed composition, it is necessary to calculate the emission based on the Total Ammoniacal Nitrogen (TAN) content, which has been done to the extent possible. In the years 1985-2006, the normative standards for N excretion ex animal and ex barn were provided in total N, while N excretion ex storage was provided in both total N and NH_4-N. From 2007, the normative standards for N excretion ex animal, ex barn and ex storage are given in both total N and TAN for all liquid manure. N excretion for solid manure and deep litter continuing is given in total N, as only a very small proportion is present as ammonium. N excretion ex storage continued is also provided in NH_4-N. The emission factors used to calculate NH_3 emission from barn (based on N ex animal), storage (based on N ex barn) and application (based on N ex storage) match the units of total N, NH_4-N and TAN in the given years mentioned above.

The normative standards for both total nitrogen excretion and the content of TAN are provided by DCA (see Chapter 5.1.3).

5.1.2 Methodology

The NH_3 emission occurs wherever the manure is exposed to the atmosphere in livestock barns, manure storages, after application of manure to the fields and from the manure deposited by grazing animals. The total NH_3 emission from animal manure is calculated as:

$$AM_t = (AM_b + AM_s + AM_{ap} + AM_g) \cdot 17/14 \quad \text{(Eq. 5.1)}$$

where:

AM_t	= total ammonia emission, kg NH_3
AM_b	= emission from manure in livestock barns, kg NH_3-N
AM_s	= emission from manure storage, kg NH_3-N
AM_{ap}	= emission from manure application to fields, kg NH_3-N
AM_g	= emission from manure deposited by animals on grass, kg NH_3-N
17/14	= conversion from NH_3-N to NH_3

For each of the elements above, NH_3 losses are calculated for each individual combination of livestock category and barn/manure type. The time the livestock spends indoors and outdoors (grazing) is taken into account. Effect of emission reducing technology in barns, such as acidification of slurry, cooling of manure, heat exchanging etc. is also taken into account (see description in Chapter 5.1.4).

a) $$\mathrm{AM_b} = N_b \cdot (100 - AE_i)/100 \cdot EF_b \quad \text{(Eq. 5.2a)}$$

a1) $$N_b = No.\cdot Nex_a \cdot \left(1 - \frac{D_g}{365}\right) \cdot Tech_i \quad \text{(Eq. 5.2b)}$$

b) $$\mathrm{AM_s} = N_s \cdot \mathrm{EF_s} \quad \text{(Eq. 5.2c)}$$

b1) $$N_s = \left(No.\cdot Nex_b \cdot \left(1 - \frac{D_g}{365}\right) \cdot Tech_i + (N_b \cdot EF_b - AM_b)^1\right) \quad \text{(Eq. 5.2d)}$$

c) $$\mathrm{AM_{ap}} = N_{ap} \cdot \mathrm{EF_{ap}} \quad \text{(Eq. 5.2e)}$$

c1) $$N_{ap} = \left(No.\cdot Nex_s \cdot \left(1 - \frac{D_g}{365}\right) \cdot Tech_i + Diff + (N_b \cdot EF_b - AM_b - (N_b \cdot EF_b - AM_b) \cdot EF_s)^1\right) \quad \text{(Eq. 5.2f)}$$

d) $$\mathrm{AM_g} = \mathrm{No.\cdot Nex_a} \cdot \left(\frac{\mathrm{D_g}}{365}\right) \cdot \mathrm{EF_g} \quad \text{(Eq. 5.2g)}$$

[1] If AE_i = 0 is this factor 0.

where:

N_b = N in barn, kg N
N_s = N in storage, kg N
N_{ap} = N in manure for application, kg N
No. = number of animals
Nex_a = N excretion from animals (normative standards), kg N per head per year
Nex_b = N excretion in barn unit (normative standards), kg N per head per year
Nex_s = N excretion in storage unit (normative standards), kg N per head per year
D_g = feeding days on grass during the year (see Table 4.14)
EF = emission factor for the given unit (barn, storage, application or grass), % NH_3-N of N
$Tech_i$ = share of emission reducing technology *i*
AE_i = abatement efficiency for the emission reducing technology *i*
Diff. = difference between emission estimate for storage in normative standards and inventory estimate, kg N (see below)

The normative standards estimated by DCA (Børsting & Hellwing, 2024) cover the N-flow from excretion from animal to the time before application of manure to soil and include emission from barn and storage. The emission factors for storage of slurry in the normative standards are based on storage with full surface crust. However, in the emission inventory estimation of the NH_3 emission from storage of slurry three different storage situations are taken into account: storage without cover, with full surface crust and with fixed cover (tent/concrete). This gives a difference in emission from storage and thereby difference in the amount of N in manure applied to soil.

Difference between emission estimate in normative standards and inventory estimate is calculated as:

$$\text{Diff.} = N_s \cdot EF_{s\ norm} - N_s \cdot EF_s \qquad \text{(Eq. 5.3)}$$

Where:

Diff. = difference between emission estimate in normative standards and inventory estimate, kg N
N_s = N in storage (normative standards), kg N
$EF_{s\ norm}$ = emission factor for storage used in estimation of normative standards, % NH_3-N of N
EF_s = emission factor for storage used in inventory estimations, % NH_3-N of N

The emission calculation for fattening pigs in 2023 housed on partly slatted and drained floor is shown below as an example, based on normative standards and emission factors given in Table 5.1. In 2023, 15.3 million fattening pigs were produced (Table 4.5); of these, 50 % are housed for 365 days a year in barn systems with partly slatted and drained floor.

Table 5.1 Normative standards and emission factors for one produced fattening pigs in 2023 (Børsting & Hellwing, 2024).

Normative standards, kg N per produced animal			Emission factors*, EF, %, NH_3-N of TAN		
TAN ex animal	TAN ex barn	TAN ex storage	Barn unit	Storage	Application
1.60	1.27	1.64	21	2.7	9.61 (slurry) 7.04 (acidified)

*The used emissions factors are described in later sections.

Calculation of the emission from fattening pigs housed on partly slatted and drained floor:

$$N_b(untreated) = (15\,331\,977\ \cdot 0.503) \cdot \frac{1.60}{1000} \cdot \left(1 - \frac{0}{365}\right) \cdot 0.987 = 11\,984\ tonnes\ N$$

$$N_b(acidified) = (15\,331\,977\ \cdot 0.503) \cdot \frac{1.60}{1000} \cdot \left(1 - \frac{0}{365}\right) \cdot 0.013 = 158\ tonnes\ N$$

$$AM_b(untreated) = 11\,984 \cdot \frac{21}{100} = 2\,517\ tonnes\ NH_3 - N$$

$$AM_b(acidified) = 158 \cdot (100 - 64)/100 \cdot \frac{21}{100} = 12\ tonnes\ NH_3 - N$$

$$N_s(untreated) = (15\,331\,997\ \cdot 0.503) \cdot \frac{1.27}{1000} \cdot \left(1 - \frac{0}{365}\right) \cdot 0.987 + \left(11\,984 \cdot \frac{21}{100} - 2\,517\right) = 9\,512\ tonnes\ N$$

$$N_s(acidified) = (15\,331\,997\ \cdot 0.503) \cdot \frac{1.27}{1000} \cdot \left(1 - \frac{0}{365}\right) \cdot 0.013 + \left(158 \cdot \frac{21}{100} - 12\right) = 147\ tonnes\ N$$

$$AM_s(untreated) = 9\,512 \cdot \frac{2.7}{100} = 257\ tonnes\ NH_3 - N$$

$$AM_s(acidified) = 147 \cdot \frac{2.7}{100} = 4\ tonnes\ NH_3 - N$$

$$Diff(untreated) = 9\,512 \cdot \frac{2.5}{100} - 9\,512 \cdot \frac{2.7}{100} = -19\ tonnes\ N$$

$$Diff(acidified) = 147 \cdot \frac{2.5}{100} - 147 \cdot \frac{2.7}{100} = -0.3\ tonnes\ N$$

$$N_{ap}(untreated) = (15\,331\,997 \cdot 0.503) \cdot \frac{1.64}{1000} \cdot 0.987 + (-19) + \left(11\,984 \cdot \frac{21}{100} - 2\,517\right) - \left(11\,984 \cdot \frac{21}{100} - 2\,517\right) \cdot \frac{2.7}{100} = 12\,264\ tonnes\ N$$

$$N_{ap}(acidified) = (15\,331\,997 \cdot 0.503) \cdot \frac{1.64}{1000} \cdot 0.013 + (-0.3) + \left(158 \cdot \frac{21}{100} - 12\right) - \left(158 \cdot \frac{21}{100} - 12\right) \cdot \frac{2.7}{100} = 182\ tonnes\ N$$

$$AM_{ap}(untreated) = 12\,264 \cdot \frac{9.61}{100} = 1\,179\ tonnes\ NH_3 - N$$

$$AM_{ap}(acidified) = 182 \cdot \frac{7.04}{100} = 13\ tonnes\ NH_3 - N$$

$$AM_{total} = 2\ 157 + 12 + 257 + 4 + 1\ 179 + 13 = 3\ 982\ tonnes\ NH_3 - N = 4\ 835\ tonnes\ NH_3$$

N excretion and emissions given in NH_3-N for all main livestock categories are shown in Appendix I.

5.1.3 Normative standards for nitrogen excretion in animal manure

The normative standards for nitrogen excretion are estimated by DCA based on research results (Laursen, 1994; Poulsen & Kristensen, 1997; Kyllingsbæk et al., 2000; Poulsen et al., 2001; Børsting & Hellwing, 2024). Since 2002, the normative standards have been adjusted annually to take into account the changes in feed composition and feed use efficiency. Values for N ex animal are provided in Appendix J for the most important livestock categories and in Appendix K based on TAN for 2007 to 2023. Values for TAN ex animal are only available for the years 2007-2023.

For heifers, a change in methodology has taken place. From 1985 to 2002, the normative standards for N ex were provided for each produced animal. This has changed from 2003, where the N ex covers N ex per AAP (annual average population – see definition in Section 4.1). For animal categories for which N ex is based on produced animal, this is noticed as a footnote in Appendix J and K.

Appendix I shows the total N excretion for the different main livestock categories from 1985 to 2023 as well as the NH_3 emission for the different main livestock categories.

5.1.4 Emission reduction technology

Over the past ten to fifteen years, is seen a growing interest in using technology to reduce the ammonia emission in livestock barns. In the inventory estimations are included reduction from cooling of manure in swine barns, acidification in cattle and swine barns, frequent removal of manure in mink barns and use of heat exchanging in barns with broilers.

The environmental technologies are closely related to the expansion of the livestock production. Due to the enlargement of the animal production, the farmer will be met by statutory environmental requirements implemented in the Environmental Approval Act for Livestock Holdings (BEK nr. 1261 af 29/11/2019 (BEK, 2019)). For some farmers, the emission reducing technology will be chosen as an opportunity to reduce the ammonia emission. The farmers apply for an Environmental Approval for livestock farming and include information on which environmental technologies are planned to be implemented to achieve the reduction of ammonia emission, as well as information regarding the expected reduction effect and the number of animals placed in the barn with the respective environmental technology. This Environmental Approvals Register for livestock farming is administrated by the Danish Environmental Protection Agency. This register also includes information on air cleaning systems, but these data have due to limited resources not been processed, and thus the reducing effect is not included in the inventory.

Information from the Environmental Approval Register is used to estimate the distribution of cooling of manure in swine barns and frequent removal of manure in mink barns.

Estimation of distribution of barns with acidifications are based on information from biggest distributor of acidification systems in Denmark.

Distribution of the use of heat exchanging in broiler barns is based on a combination of information from distributors of heat exchanging and subsidy schemes, which include subsidy to installation of heat exchangers.

Below is described the background for estimating the distribution of the included NH_3 reducing technologies in the Danish inventory.

Environmental Approval Register 2007-2017

DCE has received data sets for the Environmental Approval Register for livestock farming for the years 2007 – 2017, which are used to estimate the prevalence of ammonia emission technology in Danish livestock barns. Before 2007, no environmental approvals are available and data for 2007 also show very low prevalence of ammonia emission technology. The structure of environmental approvals was changed in 2018, so that environmental applications now is based on NH_3 emissions per m^2, whereas previously the number of animals was used. This change in unit is not comparable with the structure of the emission inventory, which makes it infeasible to use environmental approvals to estimate the prevalence of ammonia emission technologies from 2018 onwards.

It must be emphasized, that the data set covers the Environmental Approvals, which not in all cases necessarily has been implemented. It could be poor financial conditions or other circumstances, which lead to a situation, where the approval is not being realised. Therefore, the Register of Environmental Approvals for livestock farming is inserted in a database and combined with the Central Husbandry Register (CHR), which is the central register of farms and animals managed by the Danish Agricultural and Fisheries Agency. A comparison between these two registers makes it possible to check each approval with the actual development of the livestock production. In the cases where the CHR register show an expansion of the livestock production contemporary with the Environmental Approval, indicate that the approval is implemented. Around 20 % of all Environmental Approvals includes emission reducing technologies in livestock barn.

The data set for Environmental Approval Register for the years 2007 – 2017 corresponds to approximately 1800 approvals, which includes emission reducing technologies solution in barns. Data processing showed that many farmers have applied more than one approval, which indicate no realization of the first approval. Figure 5.2 shows the percentage distribution of the different reducing technologies for the 1800 farms, and slurry cooling is the most frequently used technology. Particularly the pig production seems to be active regarding use of reducing technology and thus approval for swine accounts for 76 % of all farms, cattle for 17 % and poultry for the remaining 7 %.

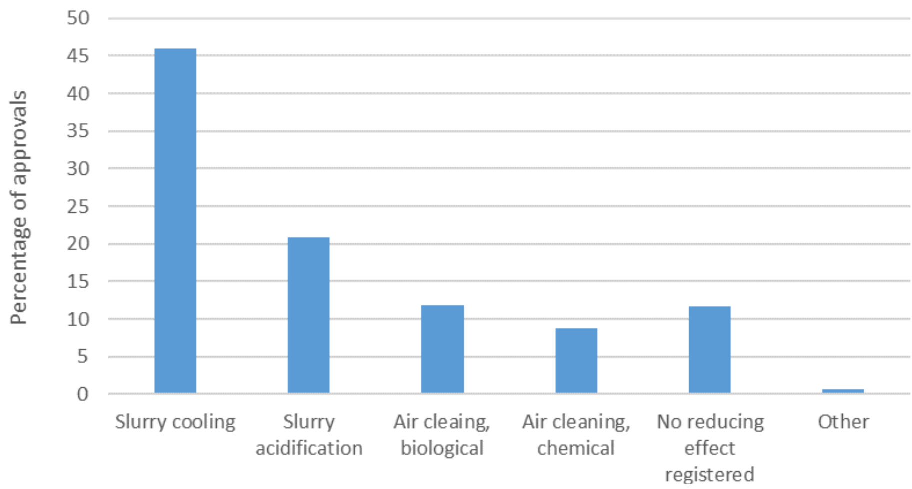

Figure 5.2 Distribution of ammonia reducing technologies in barn based on data from the Environmental Approval Register 2007 – 2017.

The review of Environmental Approval Register 2007-2017 indicates that slurry cooling seems to be the most common choice of ammonia reducing technology for the swine production, while the cattle production primarily uses slurry acidification.

Slurry cooling

Cooling of slurry only occurs in swine barns. Cooling is not only an advantage for the environment, but also profitable due to the operational cost for energy use, if the heat can be used in other production facilities – e.g. in piglet barns or farmhouse.

The estimation of distribution of slurry cooling for the years 2007-2017 is based on data from the Environmental Approval Register. Approximately 600 farmers have approval, which includes a barn system with slurry cooling. A sorting process of the data has been performed, to avoid double counting of approvals or to avoid counting approvals, which in all probability has not been realized. This sorting process leads to the conclusion that approximately 460 approvals are considered as implemented. The following assumptions are taken into account during the data processing:

- It is assumed that the Environmental Approval is not implemented, if the production has not been increased, or increased by less than 10 %. This is based on the argument that the farmer does not invest large costs in new technology, if no extension of the production takes place.
- The extension of the animal production must occur within maximum four years after the approval date; otherwise, it is assumed that the approval is not realized.
- Based on the information from the distributors of slurry cooling system, it is assumed that farmers choose to implement slurry cooling system in relation to new barn buildings. Slurry cooling systems can principally be established in existing buildings, but almost never take place in praxis.
- If CHR data show a production increase above 10 % in 2017, it is assumed that approvals for year 2014-2016 are realized.

Based on the 460 approvals (CHR numbers), which are considered realized, the number of swine is summarized for each year, distinguished between three types of swine; fattening pigs, weaners and sows. Table 5.2 shows the estimated number of animals in barns with slurry cooling system. For 2007, no approvals were considered realized, so 2007 is not included in Table 5.2. In 2008, 0.2 million swine were placed in barns with a slurry cooling system increasing to 2.2 million swine in 2017.

Table 5.2 Number of produced pigs in barn with slurry cooling based on the data from the Environmental Approval Register. (2007 no approvals were considered realized, therefore not included.)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Fattening pigs	18 428	84 439	194 095	253 899	299 762	342 337	396 743	457 236	529 249	639 288
Weaners	0	124 205	259 149	368 078	512 387	686 390	889 685	1 175 157	1 410 678	1 713 473
Sows	4 140	9 476	17 578	22 899	31 075	42 590	51 514	62 638	69 166	75 294

For the years 2018-2021, the distribution of slurry cooling is based on information from ConTerra (2022). For 2022 and 2023 are used the same distribution of slurry cooling as in 2021.

Estimation of distribution of slurry cooling

In Table 5.3, the number of animals in barns with slurry cooling system is converted to the percentage of the total livestock production. It shows that slurry cooling most frequently takes place in sow barns and for weaners, which confirms the profitably of using the heat in weaner barns. No data are available for 2022 and 2023, and therefore the slurry cooling system is kept at the same level as 2021.

Table 5.3 Distribution of slurry cooling in barn, percentage of produced pigs.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*	2023*
Fattening pigs	0.1	0.4	0.9	1.2	1.5	1.7	2.0	2.3	2.7	3.4	3.7	3.9	4.2	4.4	4.4	4.4
Weaners	0.0	0.4	0.9	1.2	1.7	2.3	2.9	3.7	4.4	5.3	5.3	5.2	5.2	5.1	5.1	5.1
Sows	0.4	0.9	1.6	2.2	3.1	4.4	5.0	6.1	6.9	7.4	8.1	8.8	9.5	10.2	10.2	10.2

* No data for 2022 and 2023 available, therefore maintained the same level as year 2021.

Slurry cooling - NH_3 reducing potential

Reduction potential for the NH_3 emission due to slurry cooling in barns is based on data from the Environmental Approvals. The approvals include information on NH_3 reduction factors for each farm depending on cooling system (temperature), the volume of air exchange in barn and pH level in manure regarding acidification. A weighted average of the NH_3 reduction factor is estimated to be 19.6 %. The Environmental Technology List states a potential up to 34 % depending on barn type. The report from ConTerra (2022) confirms a reduction potential of 20 %.

Table 5.4 Weighted annually average of NH_3 reduction emission factor for slurry cooling based on the data from the Environmental Approval Register compared with the Environmental Technologies List, %.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average	Tech list*
Cattle/swine	19.6	24.4	21.2	20.0	20.7	20.7	19.5	17.0	17.4	15.9	19.6	20

* Environmental Technologies List (SGAV, 2024) – the reduction unit is given as Watt per m^2 (28 W/m^2 = 20 % reduction).

Acidification

Data on acidification in Danish livestock barns are based on information received from a distributor of acidification systems. Today, only one single company is the main distributor of acidification systems for barns in Denmark, from where DCE have received information regarding number of sold acidification systems (JH Agro A/S, 2022). The information included:

- Name and CHR number
- Type – cattle or swine
- Animal type – dairy cattle, heifer, bulls, sows, weaners and fattening pigs
- The year that the system was put into service
- If the system was closed again, then the year the system was taken out of service
- If there is a service agreement
- If acid is received from JH Agro

Estimation of distribution of slurry acidification

The years the acidification systems are counted as active includes both the year it is put into service and the year it is taken out of service. For all farms (CHR number) with active systems number of animals and barn type are collected from the Danish fertiliser N accounts for the years 2009-2021.

The Danish fertiliser N accounts only go back to 2009, so information on number of animals for 2007 and 2008 are collected from CHR and type of barns is presume as given in the fertiliser account in 2009. For years with lack of information in the fertiliser accounts number of animals are interpolated.

The estimated number of animals in barns with acidification are shown in Table 5.5.

Table 5.5 Number of animals in barns with acidification.

	2007	2008	2009	2010	2011	2012	2013	2014
Dairy cattle, large breed	551	1 311	3 371	4 587	6 451	11 038	14 427	15 833
Dairy cattle, Jersey	350	359	926	1 595	2 340	3 354	3 540	3 752
Heifers, large breed	169	220	546	569	941	1 443	2 021	2 131
Heifers, Jersey	-	-	-	-	-	-	-	-
Bulls, large breed	-	-	909	3 143	3 200	6 060	6 322	6 405
Bulls, Jersey	-	-	-	-	-	1	1	
Sows	3 371	6 095	9 425	12 667	14 003	16 327	16 928	20 984
Fattening pigs	66 481	135 424	177 927	218 503	247 569	300 750	354 208	390 413
Weaners	152 315	197 691	241 033	314 336	290 369	305 240	326 843	378 523

	2015	2016	2017	2018	2019	2020	2021
Dairy cattle, large breed	16 089	17 306	17 321	17 120	14 462	13 324	10 385
Dairy cattle, Jersey	3 824	4 166	3 298	3 374	3 284	3 378	2 871
Heifers, large breed	1 924	1 809	1 806	1 654	1 931	1 837	1 784
Heifers, Jersey	-	-	34	77	42	39	76
Bulls, large breed	5 901	2 412	2 442	2 475	2 481	2 296	-
Bulls, Jersey	-	-	-	-	-	1	-
Sows	21 667	23 566	21 589	21 349	21 184	20 095	24 577
Fattening pigs	387 080	442 096	391 384	382 939	486 239	490 252	515 277
Weaners	427 591	501 451	541 091	549 071	519 264	486 390	494 800

The distribution of acidification systems in barns, given in percentage of number animals, is listed in Table 5.6. The percentage is calculated by dividing the total livestock production (Appendix E) with the number of animals registered in barns with acidification (Table 5.5). No data for 2022 and 2023 are available, therefore maintained the same level as year 2021.

Table 5.6 Share of animals in barns with acidification, %.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021-2023
Dairy cattle, large breed	0.12	0.27	0.69	0.93	1.32	2.18	2.88	3.29	3.35	3.53	3.54	3.46	2.97	2.75	2.16
Dairy cattle, Jersey	0.51	0.51	1.27	2.14	3.07	4.17	4.31	4.60	4.73	5.13	4.07	4.19	4.08	4.11	3.42
Heifers, large breed	0.04	0.05	0.13	0.13	0.22	0.32	0.43	0.47	0.43	0.42	0.42	0.40	0.47	0.46	0.45
Heifers, Jersey	-	-	-	-	-	-	-	-	-	-	0.08	0.18	0.09	0.08	0.14
Bulls, large breed	-	-	0.38	1.32	1.27	2.74	2.87	3.02	2.71	1.11	1.11	1.12	1.18	1.13	-
Bulls, Jersey	-	-	-	-	-	0.01	0.01	-	-	-	-	-	-	0.02	-
Sows	0.29	0.58	0.87	1.13	1.32	1.62	1.73	2.03	2.10	2.36	2.13	2.04	2.11	1.90	2.36
Fattening pigs	0.28	0.61	0.85	1.01	1.13	1.48	1.76	1.96	1.95	2.26	2.11	1.99	2.68	2.33	2.52
Weaners	0.55	0.71	0.86	1.08	0.97	1.03	1.10	1.24	1.36	1.55	1.68	1.65	1.59	1.46	1.44

Slurry acidification - NH_3 reducing potential

The Environmental Technologies List (SGAV, 2024) includes reduction factors for a series of NH_3 reduction technologies, among these a reduction factor of 33 % for acidification of cattle slurry and 64 % for acidification of swine slurry. These are used in the emission calculations.

Frequent removal of manure regarding mink barn

Frequent removal of manure reduces the emission of NH_3 from barns. A standard mink barn is defined as manure removal once a week, while a frequent removal of manure is minimum two times per week.

Estimation of distribution of frequent removal of manure

The Environmental Approval Register includes approvals for 89 farms (CHR numbers) with mink production in the period 2007-2016. However, the number of approvals is reduced to 60, because information regarding removal of manure (ones a week) and the design of manure system (slurry channel width), show that 19 farms were considered as standard barns, with no further NH_3 reducing potential. For 2007-2009, no approvals are registered.

Table 5.7 shows the number of mink (breeding females) registered in the Environmental Approval Register with frequent removal of manure for the years 2010-2018 and the percentage of the total production of mink. For 2018-2020 and 2023, no data are available and therefore the percentage of production with frequent removal of manure is considered at the same level (in percentage) as year 2017. By the end of 2020, the mink production was closed down completely and all animals were culled, so there was no production in 2021 and 2022. The production has slowly started up in 2023, and frequent removal of manure is set at the same level (in percentage) as in the year 2017.

Table 5.7 Number of breeding female mink in approvals with frequent removal of manure.

Approvals	2010	2011	2012	2013	2014	2015	2016	2017
Number of mink[1], approval for the concerned year	27 360	11 920	49 087	32 499	51 365	61 635	33 099	119 926
Total number of minks with frequent removal of manure	27 360	39 280	88 367	120 866	172 231	233 866	266 965	386 891
Total number of breeding females, millions[2]	2.70	2.75	2.95	3.12	3.31	3.39	3.25	3.42
Percentage of production with frequent removal of manure	1.0	1.4	3.0	3.9	5.2	6.9	8.2	11.3

	2018[3]	2019[3]	2020[3]	2021	2022	2023[3]
Total number of breeding females, millions[2]	3.36	2.47	2.21	NO	NO	0.01
Percentage of production with frequent removal of manure	11.3	11.3	11.3	-	-	11.3

NO – not occurring

[1] Mink = breeding female.

[2] Production based on data from Statistics Denmark.

[3] For 2018-2020 and 2023, no data are available. The percentage is maintained as year 2017.

Frequent removal of manure - NH_3 reducing potential

The Environmental Technologies List (SGAV, 2024) includes reduction factors for frequent removal of manure in mink barns, which are set to a 27 % NH_3 reduction.

Heat exchanging

Installation of heat exchanging in broiler barns have various positive effects; an economic cost saving for heat expense; quick drying of the bedding, which decreases the risk of NH_3 emission and better air quality in the barn, which is of benefit for both animals and humans.

Estimation of distribution of heat exchanging

Estimation of the use of heat exchanging in broiler barns is based on information from the largest distributor of heat exchanging system, which account for approximately 70 % of the marked (Rokkedahl Energy, 2019). DCE has received data for years 2012-2018. In addition to the information from the distributor, the estimation is also based on knowledge from subsidy schemes. Data are received from the Agency for Green Transition and Aquatic Environment. The Danish farmers had the opportunity to apply for funding for activities, with replacing of old equipment to more modern technology, including technology with ammonia reducing technology as heat exchanging, see Table 5.8. Based on the data from the subsidy schemes, it is possible to register the number of farms that have received confirmation of subsidy and also information of the animal production at these farms.

Both information from the distributor and the subsidy schemes pointed out the same development for the prevalence of heat exchangers.

It is concluded that the information based on the Environmental Approval Register is not reliable in the case of heat exchanging. Data registered in the approvals show a very limited use of heat exchanging and this underestimate is undoubtedly due to the main reason for installation of heat exchanging is reduction of operational cost. Therefore, an installation of heat exchanging is not necessarily an act that occurs in connection with an expansion of the animal production, and thus it does not release environmental approval.

Table 5.8 Subsidy schemes where subsidy for heat exchanging were possible.

Year	Subsidy schemes	Legislation
2015	Subsidy to investments in new green processes and technology in the main agriculture production	BEK No. 250 of 16 March 2015 (BEK, 2015)
2014	Subsidy to investments in green processes and technology in the main agriculture production	BEK No. 897 of 21 July 2014 (BEK, 2014)
2013	Subsidy to investments in new green processes and technology in the main agriculture production	BEK No. 569 of 31 May 2013 (BEK, 2013)
2012/2011	Subsidy to projects with investments in new green processes and technology in the main agriculture production	BEK No. 744 of 28 June 2011 (BEK, 2011)
2010	Subsidy to projects with investments in new green processes and technology in the main agriculture production	BEK No. 502 of 11 May 2010 (BEK, 2010)

Based on the data from the main distributor of heat exchanger and the data regarding the subsidy schemes, it is concluded that use of heat exchange in broiler barns takes place from 2012. Converted to the percentage of the total production in Denmark, the percentage of broiler production in barns with heat exchanging is estimated to 24 % in 2012 increasing to 90 % in 2018, Table 5.9. For 2019-2023, no data are available and therefore the percentage of production with heat exchangers is considered at the same level (in percentage) as year 2018.

Table 5.9 Distribution of heat exchanging in broiler barns, 1000 animals

	2012	2013	2014	2015	2016	2017	2018
Main distributor	24 246	27 639	17 433	14 785	1 834	3 875	999
Other distributors	2 780	2 780	2 780	2 780	2 780	2 780	2 780
Summed[1]	27 026	57 445	77 658	95 223	99 837	106 493	110 271
Total number of produced broilers	112 459	117 341	115 997	114 738	121 185	118 102	122 768
Percentage of production	24	49	67	83	82	90	90
	2019[2]	2020[2]	2021[2]	2022[2]	2023[2]		
Total number of produced broilers	124 476	121 008	118 931	115 198	118 154		
Percentage of production	90	90	90	90	90		

[1] Sum of number of broilers in barns with heat exchanger from the years before and the current year.

[2] For 2019-2023, no data are available. The percentage is maintained as year 2018.

Heat exchanging - NH_3 reducing potential

In the Environmental Technologies List (SGAV, 2024) is given a NH_3 reduction factor at 28 % for Rokkedahl heat exchanger, which is a product developed by the main distributor. Information from one of the other distributors of heat exchanger – Big Dutchman – shows a reduction factor of 29 % (LUFA Nord-West, 2012, Big Dutchman, 2019), which mean nearly at the same level as for the Rokkedahl product. A reduction factor of 28 % for all barns with heat exchanging are used.

5.1.5 Emission factors

Barn unit

The emission factors for barns vary according to the combination of barn and manure type. As an example, the emission factors for cattle barns are given in Table 5.10 based on values in the report on normative standards (Poulsen et al., 2001, Børsting & Hellwing, 2024). Appendix L lists emission factor for barns for all other livestock categories.

Table 5.10 NH_3 emission factors for barn units for cattle, 2023.

Cattle		Urine TAN	Slurry TAN	Solid manure Total N	Deep litter manure Total N
Barn type		%, loss of TAN ex animal		%, loss of N ex animal	
Tethered	Urine and solid manure	6	-	5	-
	slurry manure	-	6	-	-
Loose-housing with cubicles	Slatted floor	-	13.5	-	-
	Slatted floor and scrape	-	13.5	-	-
	Solid floor	-	20	-	-
	Drained floor	-	8	-	-
	Solid floor with tilt and scrape	-	10.4	-	-
	Solid floor with tilt	-	12	-	-
Deep litter	All	-	-	-	6
	+ solid floor	-	-	-	6
	+ slatted floor	-	13.5	-	6
	+ slatted floor and scrape	-	12	-	6
	+ solid floor and scrape	-	20	-	6
Boxes	Sloping bedded floor	-	-	-	8
	slatted floor	-	16	-	-

Storage

The emission factors used for storage are listed in Table 5.11 and are based on normative standards (Poulsen et al., 2001 and Børsting & Hellwing, 2024) but adjusted for storage cover.

Table 5.11 NH_3 emission factors for storage units, 2023.

			Urine	Slurry[1]	Solid manure	Deep litter	Biogas treated slurry	% of solid manure stored in heap on field
Cattle		Total N*	2.2	2.0	4	1.1	4.3	35
		TAN**	2.2	3.4	-	-	5.6	-
Swine	Sows	Total N*	2	2.1	19	6.5	-	50
		TAN**	2.2	2.7	-	-	-	-
	Weaners	Total N*	2	2.1	19	9.8	-	-
		TAN**	2.2	2.7	-	-	-	-
	Fattening pigs	Total N*	2	2.1	19	9.8	4.3	75
		TAN**	2.2	2.7	-	-	5.6	-
Poultry	Hens and pullets	Total N*	-	2	7.5	4.8	-	95
	Broilers	Total N*	-	-	11.5	6.8	-	85
	Turkeys	Total N*	-	-	-	6.8	-	-
	Ducks and geese	Total N*	-	-	-	8	-	-
Fur animals		Total N*	0	1.9	11.5	6.8	-	85
		TAN**	0	2.7	-	-	-	-
Horses, sheep and goats		Total N*	-	-	-	-	4.8	-

[1]The emission factors were higher in the previous years (see Appendix M).
*Total N, kg NH3-N per kg N.
**TAN, kg NH3-N per kg TAN (Total Ammonia Nitrogen).

Liquid manure

The emission from urine is, according to the normative standards, an estimated 2 % of total N ex barn unit and 2.2 % of TAN ex barn unit from a closed urine tank (Børsting & Hellwing, 2024).

By law, all slurry tanks must be covered by a fixed cover or a full surface crust to reduce NH_3 emission. Birkmose, T. & Hørfarter, R. (2019) have by a web-based tool to machine learning estimated the amount of slurry tanks covered with tent cover in Denmark in 2018. Information about the amount of slurry tanks covered with concrete lid in 2018 is given from the supervisory body for slurry tanks (Anderson, 2019). A survey has been made to estimate the amount of slurry tanks with fixed cover in the years 1985-2018 (Mikkelsen & Albrektsen, 2019). For full surface crust, it can be difficult to establish a natural full surface crust every day all year especially for tank with pig slurry. In 2023, it is assumed that 5 % of the tanks with swine slurry and biogas treated slurry and 2 % of tanks with cattle slurry and fur slurry are incompletely covered.

Emission factors for total N ex barn are based on normative standards (Børsting et al., 2021), while for TAN is based on Hansen et al. (2008). The emission factor for swine slurry without cover, with surface crust and with fixed cover (tent/concreate) is 9 %, 2 % and 1 % of total-N ex barn and 11.4%, 2.5 % and 1.3 % of TAN, respectively. For cattle, fur slurry and biogas treated slurry see Appendix M. Calculation examples of NH_3-N emission factor based on TAN for swine, cattle and fur slurry are shown in Equation 5.4.

a) $Emission_{swine\ slurry} = (0.05 \cdot 11.4\%) + (0.71 \cdot 2.5\%) + (0.24 \cdot 1.3\%) = 2.7\ \%$ (Eq. 5.4a)

b) $Emission_{cattle\ slurry} = (0.02 \cdot 10.3\%) + (0.88 \cdot 3.4\%) + (0.10 \cdot 1.7\%) = 3.4\ \%$ (Eq. 5.4b)

c) $Emission_{fur\ slurry} = (0.02 \cdot 12.9\%) + (0.69 \cdot 2.9\%) + (0.29 \cdot 1.4\%) = 2.7\ \%$ (Eq. 5.4c)

d) $Emission_{biogas} = (0.05 \cdot 27.3\%) + (0.69 \cdot 5.2\%) + (0.26 \cdot 2.6\%) = 5.6\ \%$ (Eq. 5.4d)

The emission factors for 2023 for swine (corrected), cattle (corrected), fur animals and biogas treated slurry are 2.7 %, 3.4 %, 2.7 % and 5.6 %, respectively. Emission factors for storage of slurry for all years are shown in Appendix M.

Solid manure

The emission from solid manure is based on normative standards (Børsting & Hellwing, 2024). From august 2006 the law stipulates that manure heaps should be covered, but also here a correction of the emission factor is made because the manure heaps will not be covered all time due to inflow and removal of manure. It is assumed in the inventories that 50 % of the manure heaps are covered. A calculation example of the correction for swine manure is shown in Equation 5.5, where emission factors with and without cover is 13 % and 25 % of total-N ex barn unit (Børsting et al., 2021). The same correction is made for all animal categories.

$$\text{Emission}_{\text{swine solid manure}} = (0.5 \cdot 25\%) + (0.5 \cdot 13\%) = 19\% \quad \text{(Eq. 5.5)}$$

Emission factors for cattle, swine, poultry, and fur animals are 4 %, 19 %, 7.5 % (broilers 11.5 %) and 11.5 %, respectively. See emission factors and factors for correction in Appendix N.

The emission from deep litter bedding is based on normative standards. It is assumed that the part of solid manure taken directly from the barn into the field is 65 % from cattle, 25 % from pigs, 50 % from sows, 15 % from broilers and 5 % from hens (Børsting et al., 2021) and this is taken into account. The remaining part of the solid manure is deposited in stockpiles in the field before field application, see Table 5.11.

Denitrification

Table 5.12 lists the emission factors for denitrification of solid manure and deep litter based on normative standards (Børsting et al., 2021). The emission factors are estimated based on measurements in Danish cattle and swine barn units. The factors for the remaining livestock categories are not measured directly; however, they are estimated relative to the denitrification from cattle and swine units. The fact that a certain proportion of the manure is stored in the field manure heap is taken into account (Børsting et al., 2021).

Table 5.12 Denitrification associated with storage of solid manure and deep litter in the field manure heap.

	Denitrification in % of total N ex barn unit	
	Solid manure	Deep litter
Cattle	10	5
Swine	15	15
Poultry	10	10
Horses, sheep and goats	-	10

Field application of manure

To calculate the emissions of NH_3 from animal manure applied to soils weighted emission factors are estimated and multiplied with TAN ex storage for liquid manure and N ex storage for solid manure for each animal type. Based on the normative standards (Børsting & Hellwing, 2024) the amount of TAN ex storage for liquid manure and the amount of N ex storage for solid manure are given. The weighted emission factors are estimated based on background estimates of timing, application methods, application in growing crops or on bare soil, the time from application to ploughing and extent of acidification combined with the given annual climate conditions– see further description below.

Over time, a change in practice of manure application has taken place, which is a result of changes in crop patterns and increasing environmental demands. A rise in growing winter cereals has led to a shift from manure applications in autumn to early applications in spring and changes in application technology. The requirement for an improved N utilisation in manure has also led to a greater proportion of slurry being injected or incorporated directly into the soil. Two further NH_3 reducing measures should also be mentioned. Following the legislation (BEK, 2002) a ban on traditional broad spreading of liquid manure was introduced, and manure applied to areas without vegetation had to be incorporated into the soil within six hours of application, both effective from 1 August 2003. From 2011, slurry applied on fields with grass for feeding or fields without crop cover must be injected directly into the soil. However, the injection can be substituted by acidification of the slurry. Acidification reduces the pH value and thus reduces ammonia emission, because a larger part of the nitrogen is converted to ammonium, which does not evaporate as easily as ammonia. To calculate the emission from application of manure to agricultural land, six different weighted emission factors are used; Slurry untreated/acidified during storage and application from swine and cattle, slurry from swine and cattle acidified in barns, biogas treated slurry and solid manure. For all other animals, the same emission factor as for cattle is used.

The weighted emission factors will vary from year to year depending on changes in the practice of application and emission factors for the decade. Table 5.13 presents the weighted emission factors. The decrease in the emission factor for slurry (weighted untreated or acidified during storage and application) in the period from 2000-2005 is due to broad spreading of slurry being prohibited and for 2010-2015 is due to increasing implementation of acidification. For all years see Appendix O.

Table 5.13 Percentage loss of NH_3 from application of slurry (NH_3-N of TAN ex storage) and solid manure (NH_3-N of N ex storage).

Weighted emission factor	1985	1986	1991	1996	2001	2006	2011	2015	2020	2021	2022	2023
Slurry untreated/acidified during storage and application												
Cattle[1]	47.7	47.6	44.3	35.1	23.9	11.8	9.4	10.5	10.2	10.2	10.2	10.2
Swine	24.4	24.3	24.1	17.8	13.3	11.1	9.6	9.6	9.6	9.6	9.6	9.6
Acidified slurry in barns												
Cattle	NO	NO	NO	NO	NO	NO	16.3	16.3	16.3	16.3	16.3	16.3
Swine	NO	NO	NO	NO	NO	NO	7.0	7.0	7.0	7.0	7.0	7.0
Biogas treated slurry	42.6	42.4	41.0	33.2	25.7	22.6	14.3	14.3	14.3	14.3	14.3	14.3
Solid manure	10.3	9.9	8.4	7.9	7.1	7.6	6.8	6.8	6.8	6.8	6.8	6.8

[1] Value for cattle is also used for all other animal types, except for swine.

NO – not occurring.

Activity data on manure application practices and the use of acidification and biogas are based on surveys from SEGES and Aarhus University and biogas registers made available from the Danish Energy Agency.

Acidification of slurry just before application on the fields is a used environmental technology in Denmark and the development is a result of environmental requirements. The slurry acidified in barns is considered to have the acidification effect during application.

The amount of manure acidified in storage just prior or during application is estimated by SEGES for the years 2011-2016 (Hansen, 2017) and by DCE and DCA at Aarhus University for 2017 (Nyord & Mikkelsen, 2019), see Table 5.14. No information on acidification is available for 2018-2023, so the amount for 2017 is used for 2018-2023. It is mainly cattle manure, which is acidified in storage just prior or during application, but the shares generally declined in 2016 and 2017 after years of increase.

Table 5.14 Share of liquid manure acidified in barn, storage and just before application, 2008-2023.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017-2023
Share of cattle manure, %										
Barns	0.1	0.4	0.6	0.9	1.1	1.1	1.2	1.3	1.4	1.5
Storage	0	0	0	1.2	2.6	4.6	3.1	4.2	3.8	1.9
Just before application	0	0	0	1.1	2.5	4	7.4	8.8	8.3	7.5
Share of swine manure, %										
Barns	0.1	0.3	0.5	0.6	0.6	0.7	0.8	0,8	0.9	1.0
Storage	0	0	0	0.3	0.7	1.2	0.8	1	0.4	0.2
Just before application	0	0	0	0.4	0.8	1.3	2.5	2.9	1.5	1.3

Calculation of the weighted emission factor

The weighted emission factors are based on background estimates for application practice, which is a combination of time of application, application methods, application in growing crops or on bare soil and the time from application to ploughing – see list below. For slurry (all liquid manure) the amount of manure being acidified in the barn, in storage just prior or during application is also considered. For manure acidified in barns a weighted emission factor is estimated, while the share of manure acidified in storage just prior or during application is incorporated in the weighted emission factor used for all slurry not acidified in barns or biogas treated.

List for combinations for application practice

Application time

- spring-winter (bare soil, crops, grass)
- spring-summer (grass)
- late summer-autumn (rape, seed grass)

Application method

- injection/direct incorporation
- trailing hoses
- broad spreading (prohibited for liquid manure from 2003)

Stage of crop growth

- bare soil
- growth

Length of time between application to land and incorporation of manure

- 6 or 4 hours
- less than 12 hours
- more than 12 hours
- more than a week

There is no annual statistical information on how the farmer handles the manure application in practice. The calculations are based on a study of a limited number of farms, sales figures for manure application machinery as well as development trends in LOOP areas (catchments included in the national monitoring program for the aquatic environment) (Andersen et al., 2001).

The estimate for application practice in 2001 and 2002 is, in addition to data from LOOP areas (Grant et al., 2002; Grant et al., 2003), based on information from the organisation for agricultural contractors (Kjeldal, 2002, Pers. Comm.) and a questionnaire survey of application practice implemented by Danish Agriculture (2002) involving 1 600 farmers. From 2003-2017 the estimate of application practice is based on expert judgement (Birkmose, 2016, Pers. Comm.). In 2020, a survey was made by Birkmose (2020, updated in 2023) and this is used from 2018 and onwards.

For each combination of timing, application methods, application in growing crops or on bare soil, the time from application to ploughing an emission factor have been estimated with the model ALFARM 2-model (Hafner et al., 2018, Hafner et al., 2019, Hafner et al., 2021). The emission factors are estimated for the decades 1980-1989, 1990-1999, 2000-2009 and 2010-2019 taking whether conditions for the different decades into account. For the years 2020-2023, the same emission factors as the decade 2010-2019 are used. The ALFARM 2-model is a semi-empiric model based on factual measurement of NH_3 emissions during application of manure. Specific emission factors are estimated for cattle and swine.

For solid manure, emission factors are based on the data and calculation method presented in Hansen et al (2008).

The weighted emission factors are calculated as:

$$EF_{w,i} = \frac{\sum S_j \cdot EF_j}{100} \qquad \text{(Eq. 5.6)}$$

Where:

$EF_{w,i}$ = weighted emission factor for the manure type i – see Table 5.13
S_j = share of manure applied with j application practice – see Appendix P-a-d
EF_j = emission factor for j application practice – see Appendix Q-a-d
100 = total share of manure for the manure type i

Calculation of weighted emission factor for solid manure for 2023:

$$EF_{w,solid\ manure} = \left(winter/spring_{-crop} + winter/spring_{+crop} + spring/summer_{-crop} + spring/summer_{+crop} + late\ summer/autum_{-crop}\right)/100$$

$$EF_{w,solid\ manure} = \frac{66 \cdot 5 + 7 \cdot 16 + 8 \cdot 8 + 7 \cdot 20 + 12 \cdot 3}{100} = 6.82\ \%$$

The share of manure applied per application practice for the years 1985 – 2023 for the manure types of slurry untreated/acidified during storage, slurry acidified in barns, biogas treated slurry, and solid manure is shown in Appendix P-a-d and the emission factors these combinations of application practice and manure type are shown in Appendix Q-a-d.

Grazing

Part of the manure from the animals is deposited on the field during grazing or time spent outside the barn (See chapter 4.3 and Appendix H).

For cattle, swine, sheep, goats and horses, the default emission factors from the EMEP/EEA guidebook (EMEP, 2023) are used. For deer, the same emission factor is used as for goats. Emission factor for poultry is based on Misselbrook et al. (2000). Poultry droppings are more solid than urine from swine and cattle and therefore the droppings are staying on the top of the soil instead of soaking into the soil. Emission from outdoor poultry is therefore considered to be higher than (maybe twice) for swine (Jensen, H.B (pers. comm.), 2019, Hansen, M.N. (pers. comm.), 2019). The emission factors are used for all years.

5.2 Inorganic N fertilisers

The amount of nitrogen (N) applied to soil by use of inorganic N fertiliser is estimated from sales estimates managed by the Danish Agency for Agriculture and Fisheries (LFST, 2023). As part of the annual QA/QC procedure, the sale statistics is compared with the consumption registered directly by farmers or their consultants in the Danish fertiliser N accounts controlled by Agency for Green Transition and Aquatic Environment (SGAV). The comparison indicates a difference for all years 2009-2022 and especially a significant difference for 2016, 2018 and 2020-2022 (Figure 5.3). For the years 2009-2016 and 2018, the comparison shows a higher consumption of fertilisers registered in the Danish fertiliser N accounts than in the sales statistics and thereby underestimate the amount of fertiliser, while in 2020-2022 the sales statistics have a higher amount of fertiliser. The difference in 2009-2016 is most likely caused by farmer's own import of inorganic fertilisers, which is confirmed by the LFST. It is allowed for the farmer to import fertiliser, if the consumption is related to own fields, but not for onward sale. The farmers have no interest in registering a to high estimate of their consumption of inorganic fertiliser, which indicates that the amount of applied N registered in the Danish fertiliser N accounts is more reliable for the years 2009-2016 and 2018. LFST and SGAV are aware of the situation with farmers import, and in the four years since 2017, the sales statistics include more companies selling inorganic N fertiliser, which can explain why these numbers have again increased. For 2023 no sales statistics are available.

Emission factors are based on the values given in EMEP/EEA Guidebook (EMEP, 2023).

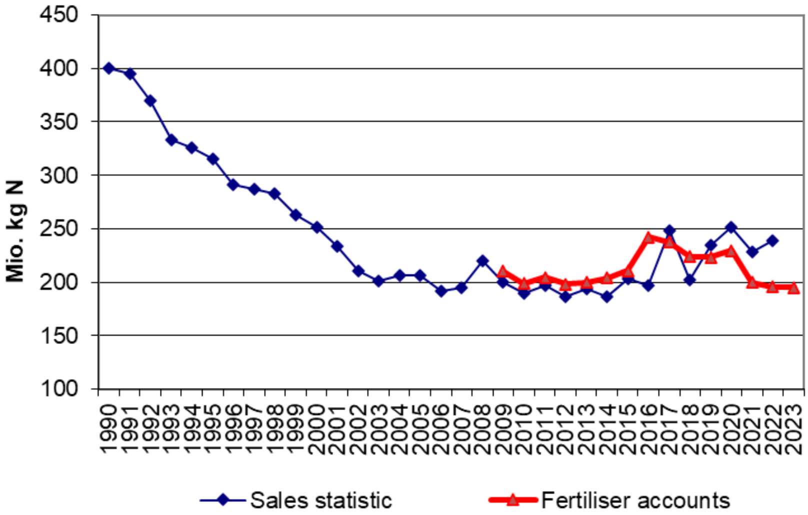

Figure 5.3 N applied from inorganic N fertiliser, sales statistic and N fertiliser account.

The emission from inorganic N fertilisers depends on type as well as amount used. Data for consumption 1985-2023 (Table 5.15) and fertiliser type and nitrogen content for 2023 (Table 5.16) are obtained from the LFST (2023), which is based on the total sale from all fertiliser suppliers.

Table 5.15 Inorganic N fertiliser consumption 1985 – 2023, kt N.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Used in agriculture[1]	398	400	316	251	206	201	213	252	229	239	197

[1] Including consumption relating to parks, sports grounds etc. – representing approximately 1 %.

Emission factors for the various fertiliser types are based on the recommendations in the EMEP/EEA Guidebook (EMEP, 2023), see Table 5.16. The same emission factors are applied for all years. Studies (Hutchings & Sommer, 2020) have shown that 21 % of the Danish agricultural area have a soil pH > 7 (high pH) and therefore are the emission factors estimated as a weighted value of 79 % EF for normal soil pH and 21 % EF for high pH given in EMEP (2023).

Table 5.16 Consumption and emission factors used for inorganic N fertiliser, 2023.

	NH_3 Emission factor[1]	Consumption[2]
	kg NH_3-N per kg N	1000 t N
Pure ammonium nitrate		
Ammonium nitrate with/without sulphur	0.025	3.12
Ammonium nitrate-urea solutions	0.025	108.40
Urea	0.084	4.72
Calcium ammonium nitrate	0.163	8.16
Calcium and boron calcium nitrate	0.025	13.88
Ammonium sulphate	0.087	0.20
Ammonium sulphate nitrate	0.087	6.77
Liquid ammonia	0.087	2.55
Liquid nitrogen	0.017	3.16
NPK-fertiliser	0.084	3.97
NK fertiliser	0.087	34.92
Other NP fertiliser types	0.025	0.89
Other fertiliser with N	0.087	3.89
Diammonphosphate	0.025	0.77
Other	0.087	0.00
Total consumption of N in inorganic N fertiliser	0.048	1.95

[1] EMEP (2023), cool climate, 79 % EF for normal soil pH and 21 % EF for high pH.
[2] Including consumption relating to parks, sports grounds etc. – representing approximately 1 %.

Since 1985, there has been a significant decrease in the use of inorganic N fertiliser (Table 5.15). This is mainly due to stricter requirements for the utilisation of nitrogen in manure and requirements for handling of manure applied to the soil. Furthermore, changes in the distribution of the different types of fertilisers have taken place and led to decreased emissions. In average, 5.9 % of the total nitrogen used in inorganic N fertiliser is emitted as NH_3 in 2023.

Table 5.17 NH_3 emission from inorganic N fertilisers and IEF (implied emission factor), 1985 – 2023.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
NH_3, tonnes	29.812	27.265	21.006	15.565	13.153	12.302	13.852	14.998	13.922	14.015	11.580
IEF, %	7.5	6.8	6.6	6.2	6.4	6.1	6.5	6.0	6.1	5.9	5.9

5.3 Cultivated crops

Plants exchange NH_3 with the atmosphere by absorbing and expelling NH_3. The amount can vary significantly depending on the plant's stage of development, conditions around the application of the fertiliser and climatic conditions at the location. A study from Schjoerring and Mattsson (2001) indicate an emission of up to 5 kg NH_3-N per hectare. Based on a literature view the emission from cultivated crops is estimated to be 2 kg N per ha for crops in rotation and 0.5 kg per ha for grass and clover. Despite uncertainties related to the use of these emission factors, the emission from cultivated crops is included in the Danish emission inventories, because otherwise the total NH_3 emission considered to be underestimated. The size of the cultivated area is based on information from Statistics Denmark.

Table 5.18 Emission factor used for crops, kg N per ha.

All crops ex grass	2
Grass/clover in a rotation	0.5
Permanent/long-term grass	0.5

From 1985 to 2023, the NH_3 emission from cultivated crops has increased from approximately 4 900 to 5 200 tonnes of NH_3-N corresponding to an increase of 6 %, due to changes in the distribution between crop types.

5.4 Sewage sludge

Some of the sludge from wastewater treatment is applied as fertiliser to agricultural soil. Information regarding the amount of sewage sludge applied on agricultural soil as fertiliser, is based on information from the Danish Environmental Protection Agency (DEPA), and covers the years 1987-2002, 2005, 2008-2009, 2013-2022 (latest DEPA, 2024). For 1985-1986 the amount of sewage sludge applied is based on expert judgement. In the intervening years, the amount of sewage sludge applied is interpolated and 2023 is based on an average of the years 2020-2022.

The N-content for the years 1985-2002 varies and is based on information in the reports from DEPA and expert judgement. For the years 2003-2019 it is assumed to be 4.75 kg N per kg dry matter (DEPA, 2009) and 6.0 kg N per kg dry matter for the years 2020-2022 (DEPA, 2022a).

The emission factor from EMEP/EEA Guidebook (EMEP, 2023) of 0.13 kg NH_3/kg N applied is used.

Table 5.19 shows an increasing amount of sewage sludge being applied to agricultural soil from 1985 to the mid-1990s, which is replaced by a decrease until 2008 due to use of the product in industrial processes, e.g. in cement production and the production of sandblasting materials. From 2008 and forward, the amount of applied sewage sludge on agricultural soils is stabilised at the same level.

Table 5.19 Emission from sewage sludge applied to agricultural land 1985-2023.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Sewage sludge applied to agricultural soil, kt dry matter	50	78	112	84	57	76	85	99	84	74	86
N content, %.	4.0	4.0	4.1	4.3	4.8	4.8	4.8	6.0	6.0	6.0	6.0
N applied to agricultural soil, tonnes	2 000	3 115	4 635	3 625	2 710	3 622	4 038	5 940	5 040	4 440	5 140
NH_3-N emission, tonnes NH_3	260	405	603	471	352	471	525	772	655	577	668

5.5 Other organic fertilisers

Other organic fertilisers include emission from industrial wastes, which is sludge from industries and 'other biomass' includes digestate from other types of biomasses aside from manure treated in biogas plants, both applied to agricultural soils as fertiliser. Information about the amount of industrial waste applied on agricultural soil and the content of nitrogen is obtained from a series of reports published by the Danish Environmental Protection Agency. The recent official figures regarding the amount of sludge from industrial waste are data covering until 2001 (Petersen & Kielland, 2003). From 2005, the amount of N from sludge from industries is based on the information registered in the annual N fertiliser accounts controlled and made available by Agency for Green Transition and Aquatic Environment (SGAV). Amounts in 2002-2004 are interpolated.

The amount of nitrogen applied to soil from biomass treated in biogas plants (other than manure) is based on the energy production in the biogas plants given in PJ and N per PJ, subtracting the amount of N from NH_3 emission at the biogas plant itself and the amount of N from manure. Production in PJ is given in the annual energy statistics provided by the Danish Energy Agency (DEA, 2024a) and N per PJ is estimated as a standard value of 9.4 tonne N per PJ based on an average of N in feedstock and energy production in 2016-2019. The amount of NH_3 emission from the feedstock at the biogas plants used for subtraction in the calculation is reported in the waste sector in the emission inventory.

The amount of N in feedstock is estimated based on information from EMEP (2023), IPCC (2019) and national values, see Table 5.20. For each feedstock type the most suitable overall group of feedstocks is defined.

Table 5.20 N content in feedstock.

EMEP/EEA Guidebook	N content of fresh matter (kg per kg)
Green waste (grass, ect.)	0.0046
Food waste (food processing)	0.0051
Municipal organic waste	0.0068
Mixed types of feedstocks	0.0055*
IPCC	N content of dry matter (kg per kg)
Maize and corn	0.006
Grass	0.0025
National	N content of dry matter (kg per kg)
Straw	0.0053
Sewage sludge	0.06

*Average of EF for green waste, food waste and municipal organic waste.

The emission factor from EMEP/EEA Guidebook (EMEP, 2023) of 0.08 kg NH_3/kg N applied is used.

Table 5.21 Activity data emission of NH_3–N from other organic fertiliser, 1985-2023.

		1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Industrial waste	t N	1 500	1 529	4 445	5 147	2 359	3 401	4 455	5 283	5 425	5 800	5 148
Other biomass	t N	3	7	12	21	30	37	56	192	238	264	289
N applied on soil	t N	1 503	1 536	4 457	5 168	2 389	3 438	4 511	5 475	5 663	6 064	5 437
Emission	t NH_3-N	99	101	294	340	157	226	297	361	373	399	358

5.6 Crop residue

NH_3 emission from crop residues is a new emission source included in the EMEP/EEA Guidebook 2023 version. These emissions were included first time in the 2025 submission and cover the years 1985 - 2023. Crop residues are defined as those parts of the crop left on the soil surface following harvest. The ammonia emissions are related to the amount of N content of the residue left on the soil surface.

5.6.1 Emission

NH_3 emission mainly depends on the N content in crop residues above ground, which approximately follows development in area. However, the emission is also affected by the crop yield, which differs from year to year, except for vegetables, where the same N content is used for all years. Grass-clover and especially grass-clover in rotation are the main contributors, which mean that grass-clover covers 87 % of the total NH_3 emission in 2023.

From 1985 to 2023, the NH_3 emissions decreased, which is mainly driven by change in emission from grass-clover and mainly the fall in emission from grass-clover outside rotation. The main reason for lower emission from grass-clover outside rotation is due to more extensive cultivation of the fields, which lowers the harvest yield. In attempts to reduce N-surplus to the environment, the farmers can use a variety of subsidy schemes for more extensive cultivation, where no fertilization or limited fertilization is allowed (e.g. by grassing animals).

Table 5.22 NH_3 emission from crop residue, kt NH_3.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Potato	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.03	0.03	0.04
Alfalfa	0.02	0.05	0.05	0.04	0.03	0.04	0.02	0.01	0.00	0.00	0.00
Tubers	0.10	0.10	0.06	0.04	0.03	0.02	0.02	0.03	0.03	0.02	0.02
Non-N fixing forages	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00
N fixing forages	0.08	0.11	0.18	0.23	0.13	0.10	0.09	0.09	0.07	0.08	0.05
Perennial grasses	NO	NO	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.01
Grass-clover mixtures, in rotation	1.22	1.19	1.06	1.15	1.25	1.62	1.40	1.40	1.37	1.34	0.99
Grass-clover mixtures, outside rotation	0.56	0.58	0.52	0.44	0.39	0.38	0.49	0.27	0.28	0.20	0.16
Vegetables	0.12	0.10	0.08	0.06	0.05	0.06	0.06	0.07	0.07	0.06	0.06
Total emission	2.13	2.15	2.02	2.02	1.92	2.25	2.11	1.91	1.87	1.76	1.33

No NH_3 emission is expected from crop types with N-concentration in crop residues (N_{AG}) lower than 0.0132 kg N per kg dry matter (Ruijter and Huijsmans (2019), which is the case for cereal crops, maize and beans/pulses.

5.6.2 Calculation methods

Same dataset for N content in crop residues above ground is used for calculating the NH_3 emission and the N_2O emission (refer to section 12.2.4). The N in crop residues above ground (N-load, kg N/ha) is estimated based on the Tier 1 methodology described in the 2019 IPCC Refinement. However, country specific estimates are used for crop yield and dry matter content, based on data from Statistics Denmark, and thus varies from year to year.

No estimates are given for vegetables in the IPCC 2019 Refinement, therefore N-content in crop residues above ground are calculated based on data from a Dutch paper: Ruijter and Huijsmans (2019).

Besides the N-content in crop residues above ground, the NH_3 emission also depends on for how long the crop residue is laying on the soil surface, expressed as the contribution factor (F). Emissions only take place if the crop residues remain on the soil surface longer than three days after harvesting. Currently, it is assumed that all crop residues are laying longer than three days and thus contribute to NH_3 emission, which corresponds to a contribution factor of 1. If incorporation in soil takes place within three days after harvest the contribution factor should be 0 and thus no emission is expected.

The NH_3 emission factor is based on a regression equation with relationship between NH_3 emission and N content in crop residues above ground expressed as g N per kg dry matter, from a Dutch study (see section 5.6.3 below).

$$NH_3 - N_{CropResidues,i} = \sum(A_i \cdot N_{load} \cdot F_i \cdot EF_i) \quad \text{(Eq. 5.7)}$$

$EF_i = 0.41 \cdot N_{content,i} - 5.42$ (Eq. 5.8)

Where:

NH_3-$N_{CropResidues}$ = NH_3 volatilization from crop residues i (kg NH3-N/year)
Σ = Sum over all crops
A = Cultivated area for crop type i (ha)
N-load = N in crop residues above ground, crop type i (kg N/ha)
F = Contributing fraction for crop type i. Incorporation within three days after harvest means no contribution (F=0). In case no covering by soil during harvesting (F=1).
Efi = Emission factor as calculated by regression model, crop type i (% NH_3-N/ha of total N-load (kg N/ha).
N-$content_i$ = The N-content for crop type i (kg N/kg dm)

5.6.3 Activity data and emission factor

The cultivated area is based on information from Statistics Denmark. As mentioned above, the N-load in crop residues above ground is calculated within the calculation of N_2O emission from crop residues based on IPCC default values. Except for vegetables, where data are from a Dutch study (Ruijter and Huijsmans, 2019), under the assumption that production conditions between Danish and the Netherlands can be considered as comparable. For vegetables which is not listed in the Dutch paper (e.g. sunchoke, parsnip, parsley root), values for a similar vegetable are used (beetroot).

The Danish vegetables production is dominated by carrots, onions, peas for consumption, cabbage and lettuce, which contribute with approximately 70% of total area.

As mentioned above, the contribution factor for all crop types is assumed to be 1, which indicates that no crop residues are incorporated in soil or covered by soil within three days after harvesting.

The NH_3 emission factor given in the EMEP/EEA Guidebook 2023 is based on the paper from Ruijter and Huijsmans (2019), where a regression equation is provided on results from nine NH_3 measurements studies. Variables: N-content (N per dry matter) is needed to estimate the NH_3 emission factor. The Dutch study shows that no NH_3 emission is expected if the N-content is lower than 0.0132 kg N. The N-content in crop residues above ground is the same as the IPCC term "N_{AG}".

Table 5.23 shows the list of the crop types that contribute to NH_3 emissions and includes activity data for cultivated areas, the N-load and the contribution factor used for the 2023-emission calculation.

Table 5.23 Activity data and emission factor used for NH_3 emission calculation, 2023.

	Area	Total N in residue above ground	N load	N-content of above-ground residue	Contributing fraction (F)	EF	Emission per ha	Emission
	ha	kg N	kg N/ha	kg N/kg DM		%	kg NH_3-N/ha	kt NH_3
Potato	61 139	1 258 515	20.6	0.019	1	2.37	0.49	0.04
Alfalfa	480	26 309	54.8	0.027	1	5.65	3.10	0.002
Tubers	35 280	851 953	24.1	0.019	1	2.37	0.57	0.02
Non-N fixing forages	21 453	486 527	22.7	0.015	1	0.73	0.17	0.004
N fixing forages	21 453	726 230	33.9	0.027	1	5.65	1.91	0.05
Perennial grasses	167 654	597 275	3.6	0.015	1	0.73	0.03	0.01
Grass-clover mixtures, in rotation	361 030	16 936 950	46.9	0.025	1	4.83	2.27	0.99
Grass-clover mixtures, outside rotation	226 438	2 688 987	11.9	0.025	1	4.83	0.57	0.16
Vegetables:								
Cauliflower	370	48 924	132.2	0.036	1	9.26	12.24	0.01
Broccoli	406	63 230	155.8	0.037	1	9.59	14.93	0.01
White cabbage/concical cabbage	625	82 841	132.6	0.025	1	4.99	6.62	0.01
Red cabbage	163	21 170	129.8	0.030	1	6.88	8.93	0.002
Chinese cabbage	37	2 629	71	0.035	1	9.09	6.46	<0.001
Kale	0	0	60	0.025	1	4.99	3.00	<0.001
Sprouts	0	0	167.8	0.021	1	3.27	5.49	<0.001
Green cabbage	224	31 340	140	0.029	1	6.43	9.00	0.002
Leek	287	23 515	81.8	0.031	1	7.09	5.80	0.002
Lettuce, iceberg	1158	65 185	56.3	0.038	1	10.28	5.79	0.01
Lettuce, leaf of other kinds	0	0	22.3	0.034	1	8.68	1.94	<0.001
Spinach	449	18 853	42	0.042	1	11.96	5.02	0.003
Asparagus	220	5 179	23.5	0.029	1	6.39	1.50	<0.001
Celery	0	0	37.5	0.021	1	3.11	1.17	<0.001
Courgettes	53	8 738	165	0.038	1	9.96	16.43	0.001
Winter carrots	2226	175 891	79	0.021	1	3.03	2.39	0.01
Celeriac	106	7 952	75	0.024	1	4.38	3.28	<0.001
Beetroot	653	62 016	95	0.025	1	4.99	4.74	0.004
French beans	0	0	77.3	0.026	1	5.24	4.05	<0.001
Lettuce, leaf of other kinds	2	52	22.3	0.034	1	8.68	1.94	<0.001
Tomato, cucumbers, herbs	505	41 621	82.4	0.027	1	5.61	4.62	0.003
Sweet corn	337	40 472	120	0.017	1	1.43	1.71	0.001
Peas	831	106 119	127.7	0.024	1	4.34	5.54	0.01
Total emission								1.33

5.7 Ammonia treated straw

The addition of NH_3 promotes the breakdown of straw, which increases the digestion processes. NH_3 treated straw is used as cattle feed. Information on NH_3 used for treatment of straw used to be collected directly from the suppliers and it is assumed that the sale of NH_3 in the second half of the year is used for the treatment of straw with NH_3. Law banned the NH_3 treatment of straw in 2006. However, due to wet weather conditions a dispensation to the law can be given in affected areas and dispensations are given in different areas every year from 2006 and forward. No statistics are provided for the dispensations but from 2021 Agency for Green Transition and Aquatic Environment collect data for NH_3 sales and make them available for the inventory.

The emission from ammonia treatment of straw is estimated to 0.65 kg NH_3-N per kg N added to straw. This estimate is based on few studies and depends on the dry matter content in straw and the storage conditions (Andersen et al., 1999, Andersen et al., 2001). There are no statistics regarding how the farmers handle the ammonia treated straw in practice, so the emission factor is highly uncertain.

Table 5.24 shows that since 1985 there has been a considerable decrease in the emission from NH_3 treated straw until the ban in 2006.

Table 5.24 Emission from NH_3 treated straw, 1985-2023, tonnes NH_3-N.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Consumption of NH_3-N	8 300	12 936	8 421	3 131	329	200	200	200	306	104	9
Emission of NH_3-N	5 395	8 408	5 474	2 035	214	130	130	130	199	68	6

5.8 NH_3 emission from dogs and cats

A calculation method and emission factors are in EMEP/EEA Guidebook (EMEP, 2023) given for emission of NH_3 from pets. In the Danish inventory emission from dogs and cats are estimated and reported in sector 6A Other.

The number of dogs and cats are based on information's from the European Pet Food Federation (2024). Number is given for 2000, 2010, 2012, 2014 and 2016-2022. For dogs, the number of animals for the years 1985-1999 are based on a linear trend extrapolation and for 2001-2009 the numbers are based on interpolation. For cats the number of animals for the years 1985-1999 and 2001-2009 are based on a polynomial trend. For the years 2011, 2013 and 2015 the numbers are based on interpolation. No information is given for 2023 therefore the numbers are set at the same level as in 2022.

Table 5.25 Number of dogs and cats, unit 1 000.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Dogs	503	517	532	546	563	580	592	607	610	643	643
Cats	557	593	623	646	663	673	684	670	680	698	698

The emission factors given in the EMEP/EEA Guidebook (EMEP, 2023) are used, 0.13 and 0.74 kg NH_3 per AAP for cats and dogs, respectively.

Emission of NH_3 is shown in Table 7.2. The emissions are increasing from 1985 to 2023 due to an increase in the number of animals.

Table 5.26 Emission of NH_3, kt.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Dogs	0.37	0.38	0.39	0.40	0.42	0.43	0.44	0.45	0.45	0.48	0.48
Cats	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09

6 Particulate matter

Particulate matter (PM) emissions originate from the livestock barns, from field operations and from field burning of agricultural residues. In the Danish inventory, PM from handling of crop products is not included as there is no default methodology provided in the EMEP/EEA Guidebook and no national activity data, or emission factors are available.

The PM emissions from the agricultural sector mainly consist of larger particles. In the reporting under CLRTAP particulate matter is reported as TSP, PM_{10} and $PM_{2.5}$. Tiny airborne particles or aerosols that are smaller than 100 µm are collectively referred to as total suspended particles (TSP). PM_{10} is the fraction of suspended particulate matter with an aerodynamic diameter of 10 µm or smaller and $PM_{2.5}$ represents particles smaller than 2.5 µm.

Agriculture accounts for 77 % of the total TSP emissions in 2023 and the emission shares for PM_{10} and $PM_{2.5}$ are 38 % and 9 %, respectively. Most agricultural emissions originate from field operations, contributing 89 % of the agricultural emissions. Emissions from livestock production contributed 11 % and the field burning of agricultural residues contributed less than 1 % to the agricultural emissions. A description of the calculation methodology is set out below. The calculation from field burning is described in Chapter 7.

6.1 Livestock production

The PM emissions from animal production include dust from barn systems. In 2023, these emissions, expressed as TSP, were estimated to 6.65 kt. Of this, 51 % relates to swine production. The emissions from cattle and poultry contributed 21 % and 27 %, respectively.

Table 6.1 shows emission of PM from livestock production 1985 – 2023. See Appendix R for PM emission for all years distributed on the different animal categories. The emission of TSP and PM_{10} increases from 1985 to 2021 but decreases in 2022 and 2023, mainly due to changes in number of animals. The $PM_{2.5}$ emission decreases from 1985 to 2005 and from 2005 to 2023 it is almost unaltered.

Table 6.1 PM emission from livestock, 1985-2023, kt.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
TSP	6.75	6.58	7.15	7.18	7.23	7.25	7.06	7.59	7.60	7.33	6.65
PM_{10}	2.44	2.34	2.55	2.62	2.56	2.56	2.43	2.58	2.58	2.50	2.29
$PM_{2.5}$	0.78	0.69	0.67	0.63	0.53	0.56	0.56	0.57	0.56	0.55	0.54

6.1.1 Calculation method

The estimation of the PM emission is based on the EMEP/EEA Guidebook (EMEP, 2023). The PM emission is calculated using equation 6.1 and thus distinguishes between emission from liquid and solid manure.

$$PM_{10} = No.\cdot \left(1 - \frac{D_G}{365}\right) \cdot \left(EF_{PM10_S} \cdot B_S + EF_{PM10_L} \cdot B_L\right) \quad \text{(Eq. 6.1)}$$

where:

PM_{10} = emission of PM_{10}, kg per year
No. = number of average annual population (AAP – see definition in section 4.1)
D_G = actual days on grass
$EF_{PM10, S \text{ or } L}$ = emission factor for solid or liquid manure, kg per head per year
$B_{S \text{ or } L}$ = % of solid or liquid manure

The main types of barns are divided into subcategories with a distinction for each category between solid and slurry-based barn systems. The PM emission is furthermore related to the number of days the animal is in the barn. The PM emission from grazing animals is considered negligible. The number of grazing days for 2023 is listed in Table 4.14.

6.1.2 Activity data

Calculation of PM from livestock is based on data for the number of animals, type barns and manure and days on grass.

6.1.3 Emission factors

The emission factors for TSP, PM_{10} and $PM_{2.5}$ are those recommended in the EMEP/EEA Guidebook, (EMEP, 2023). The same emissions factors are used for all years.

Table 6.2 shows the emission factors for livestock. The emission factors are given for a range of livestock categories and separated into solid or slurry-based systems.

Table 6.2 PM emission factors from animal barn systems, kg per AAP (defined in section 4.1).

		Emission factor		
Livestock category	Manure type	TSP	PM_{10}	$PM_{2.5}$
Cattle:				
Dairy cattle	Slurry	1.81	0.83	0.54
	Solid	0.94	0.43	0.28
Calves < ½ year	Slurry	0.34	0.15	0.10
	Solid	0.35	0.16	0.10
Beef cattle	Slurry	0.69	0.32	0.21
	Solid	0.52	0.24	0.16
Heifers[1]	Slurry	1.07	0.49	0.32
	Solid	0.64	0.30	0.19
Suckling cows[2]	Slurry	0.69	0.32	0.21
	Solid	0.52	0.24	0.16
Swine:				
Sows	Slurry	0.62	0.17	0.01
	Solid	0.62	0.17	0.01
Weaners	Slurry	0.27	0.05	0.002
	Solid[3]	0.27	0.05	0.002
Fattening pigs	Slurry	1.05	0.14	0.01
	Solid	1.05	0.14	0.01
Poultry:				
Laying hens	Solid	0.19	0.04	0.003
Broilers	Solid	0.04	0.02	0.002
Turkeys	Solid	0.11	0.11	0.02
Ducks	Solid	0.14	0.14	0.02
Geese	Solid	0.24	0.24	0.03
Other:				
Horses	Solid	0.48	0.22	0.14
Sheep	Solid	0.14	0.06	0.02
Goats	Solid	0.14	0.06	0.02
Fur animals	Slurry	0.02	0.008	0.004

[1] Average of "calves" and "dairy cattle".
[2] Assumed the same value as for "beef cattle".
[3] Same as slurry-based systems.

6.2 Field operations

In the EMEP/EEA Guidebook, a methodology is provided to account for PM emissions from field operations, which include emissions from crop harvesting, cultivation of soil, and the cleaning and drying of crops (EMEP, 2023). Harvesting and soil cultivation are the predominant sources of PM and the emission depends on crop type, soil type, cultivation method and the weather before and during work.

The emission of TSP, PM_{10} and $PM_{2.5}$ are shown in Table 6.3. The emission of TSP has decreased 14 % from 1985 to 2023 due to a decrease in the area of cultivated crops and number of treatments of the fields.

Table 6.3 Emissions of TSP, PM_{10} and $PM_{2.5}$ from field operations, tonnes.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
TSP	65 954	66 808	60 819	60 576	52 308	54 376	55 993	58 508	58 838	58 268	56 592
PM_{10}	6 595	6 681	6 082	6 058	5 231	5 438	5 599	5 851	5 884	5 827	5 659
$PM_{2.5}$	490	511	463	464	420	431	438	445	448	444	431

6.2.1 Calculation method

The methodology provided in the EMEP/EEA Guidebook on emission calculations from field operations is shown below:

$$E_{PM} = EF_{PM} \cdot AR \cdot No._{o} \qquad \text{(Eq. 6.2)}$$

where:

E_{PM}	= emission of PM_{10}, $PM_{2.5}$ or TSP, kg
EF_{PM}	= emission factor for crop and operation type, kg per ha
AR	= area of crops, ha
$No._{o}$	= production cycles, the number of times the operations are performed

6.2.2 Activity data

For activity data, area of cultivated crops and number of operations for each crop are used. The area of crops is estimated by Statistics Denmark (DSt, 2024) and number of operations are based on budget estimates made by SEGES. See Appendix S for area of cultivated crops and Appendix T for number of operations divided into soil cultivation, harvesting, cleaning and drying.

Soil cultivation is operations such as ploughing, harrowing, fertiliser application, sowing, rolling and pesticide spraying in the fields. For harvesting, the operations combine harvesting, lifting potatoes, beets etc. and mowing. Drying includes drying and cooling of crops. For cleaning, the operations are straw baling, potato and beet topping and hay raking.

The number of operations changes over time for some crop types, especially change in number of soil cultivations. Number of soil cultivations decreases from 2001-2002 for cereals, rape and grass and increases again in 2017-2023, which affects the emission of PM.

6.2.3 Emission factors

Emission factors for crops and operation type are given in Table 6.4 (EMEP, 2023). Emission factors for wet climate conditions are the most suitable for Danish conditions.

Table 6.4 Emission factor for field operations, kg per ha.

Crop	Soil cultivation	Harvesting	Cleaning	Drying
PM_{10}				
Wheat	0.25[a]	0.27[b]	0.19[a]	0.56[a]
Rye	0.25[a]	0.2[b]	0.16[a]	0.37[a]
Barley	0.25[a]	0.23[b]	0.16[a]	0.43[a]
Oat	0.25[a]	0.34[b]	0.25[a]	0.66[a]
Other arable	0.25[a]	0.26[c]	0.19[c]	0.51[c]
Grass	0.25[a]	0.25[a]	0[a]	0[a]
$PM_{2.5}$				
Wheat	0.015[a]	0.02[a]	0.009[a]	0.168[a]
Rye	0.015[a]	0.015[a]	0.008[a]	0.111[a]
Barley	0.015[a]	0.016[a]	0.008[a]	0.129[a]
Oat	0.015[a]	0.025[a]	0.0125[a]	0.198[a]
Other arable	0.015[a]	0.019[c]	0.009[c]	0.152[c]
Grass	0.015[a]	0.01[a]	0[a]	0[a]
TSP[d]				
Wheat	2.5	2.7	1.9	5.6
Rye	2.5	2	1.6	3.7
Barley	2.5	2.3	1.6	4.3
Oat	2.5	3.4	2.5	6.6
Other arable	2.5	2.6	1.9	5.1
Grass	2.5	2.5	0	0

[a] EMEP (2023).
[b] Van der Hoek & Hinz (2007).
[c] Average of wheat, rye, barley and oat.
[d] PM_{10} multiplied by 10 (van der Hoek & Hinz, 2007).

7 Field burning of agricultural residues

The field burning of agricultural residues has been prohibited in Denmark since 1990 (LBK, 1989; BEK, 1991) and may only take place in connection with the production of grass seeds on fields with repeated production (straw from seeds of grass) and in cases of wet or broken bales of straw (mixed cereals).

Field burning produces emissions of a series of different pollutants: NH_3, CH_4, N_2O, NO_x, CO, CO_2, SO_2, NMVOC, PM, heavy metals, dioxins, PAHs, HCB and PCBs. Default values given by the EMEP/EEA Guidebook (EMEP, 2023) are used for NH_3, NO_x, CO, SO_2, NMVOC, PM, BC, heavy metals and dioxins. For PAHs, emission factors are based on Jenkins (1996) and for N_2O, CH_4 and CO_2 the emission factors are based on Andreae (2019). Emission factors for HCB are based on Hübner (2001) and for PCBs on Black et al. (2012).

Figure 7.1 shows the trend of the emission of NH_3, PM_{10}, $PM_{2.5}$, CH_4 and NMVOC from field burning for 1985-2023. The large decrease in emissions in 1990 is due to the ban on field burning of agricultural residues. The trend of the emission of the remaining pollutants is similar to the ones shown. Emissions for all pollutants and all years are shown in Appendix U.

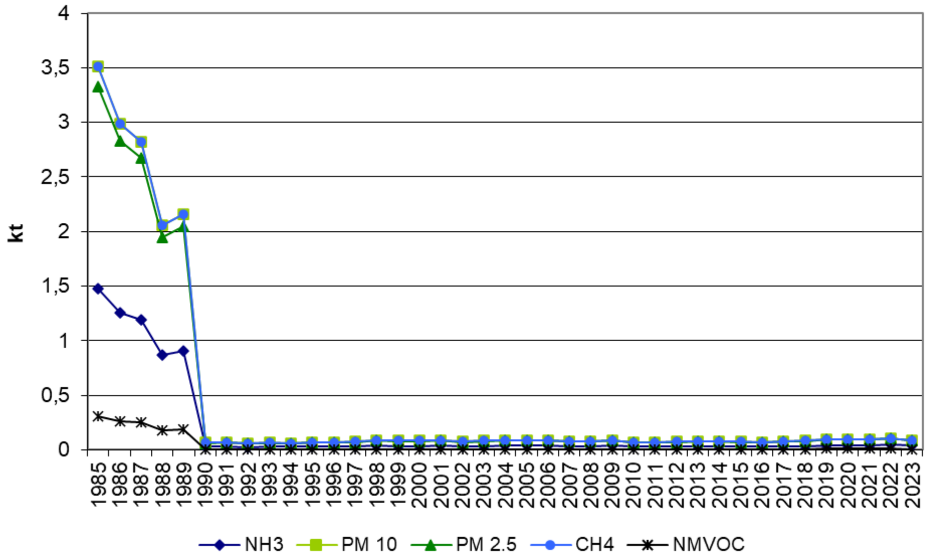

Figure 7.1 Trend of the emission of selected pollutants from field burning of agricultural residues.

7.1 Calculation method

The equation for calculating the emission is shown below. The parameters used for the calculation of emissions are given in Table 7.1, Table 7.2 (emission factors) and Table 7.3. EFs are the same for all years.

$$Emi = BB \cdot \frac{EF}{1\,000} \cdot CF \qquad \text{(Eq. 7.1)}$$

$$BB = \frac{CP \cdot FB \cdot FR_{DM}}{1\,000}$$

Where:

Emi = emission of pollutants, kt
BB = total burned biomass, kt dry matter (DM)
CP = crop production, t
FB = fraction burned in fields
FR_{DM} = dry matter fraction of residue
EF = emission factor, g per kg DM
CF = combustion factor

Table 7.1 Parameters for estimating emissions from field burning, 2023.

	Crop production	Fraction burned in fields	Dry matter fraction of residue[a]	Total biomass burned	Combustion factor[b]
	tonnes			kt DM	
Mixed cereals	4 881 100	0.001	0.85	4.15	0.90
Straw from seeds of grass	434 500	0.15	0.85	13.04	0.90

[a] SEGES (2005).
[b] EMEP (2023).

7.2 Activity data

The amount of burnt straw from the grass seed production is estimated as 18 % in 1985 decreasing to 15 % in 1990 onwards of the total amount produced. The amount of burnt bales of wet straw is estimated as 0.1 % of total amount of straw. Both estimates are based on expert judgement by SEGES (Feidenhans'l, 2009, Pers. Comm.). The total amounts of burned biomass are based on data for crop production from Statistics Denmark and dry matter fraction of the crops (SEGES, 2005).

7.3 Emission factor

Table 7.2 shows the emission factors used by all pollutants from field burning of agricultural residues and the emission for the year 2023.

Table 7.2 Emission factors and emissions for the different pollutants from field burning of agricultural residues, 2023.

Pollutant	EF	Unit for EF	Emission 2023	Unit for emission
NH_3	2.3	g/kg dm	0.04	kt
CH_4	5.7	g/kg dm	0.09	kt
N_2O	0.09	g/kg dm	0.001	kt
NO_x	2.3	g/kg dm	0.04	kt
CO	66.7	g/kg dm	1.03	kt
CO_2	1.43	kg/kg dm	22.1	kt
SO_2	0.5	g/kg dm	0.01	kt
NMVOC	0.5	g/kg dm	0.01	kt
PM				
TSP	5.8	g/kg dm	0.09	kt
PM_{10}	5.7	g/kg dm	0.09	kt
$PM_{2.5}$	5.4	g/kg dm	0.08	kt
BC	0.5	g/kg dm	0.01	kt
Metals				
Pb	0.11	mg/kg dm	0.002	t
Cd	0.88	mg/kg dm	0.01	t
Hg	0.14	mg/kg dm	0.002	t
As	0.0064	mg/kg dm	0.0001	t
Cr	0.08	mg/kg dm	0.001	t
Ni	0.052	mg/kg dm	0.0008	t
Se	0.02	mg/kg dm	0.0003	t
Zn	0.56	mg/kg dm	0.009	t
Cu	0.073	mg/kg dm	0.001	t
Dioxins	500	ng TEQ/t	0.03	g/TEQ
PAHs				
Benzo(a)pyrene	0.41	µg/kg dm	0.01	t
Benzo(b)fluoranthene	1.14	µg/kg dm	0.02	t
Benzo(k)fluoranthene	0.48	µg/kg dm	0.01	t
Indeno(1,2,3-cd)pyrene	0.67	µg/kg dm	0.01	t
HCB - mixed cereals[1]	0.003	g/ton		
HCB - grass seed[1]	0.002	g/ton		
HCB			0.13	kg
PCBs - mixed cereals	3	µg TEQ/t		
PCBs - grass seed	0.05	µg TEQ/t		
PCBs			0.00002	kg

[1] See Chapter 7.1.4 for conversion of EF from the unit ha to g per t.

References: EMEP (2023), Jenkins (1996), Andreae (2019), Hübner (2001).

7.4 Conversion of EF for HCB

The emission factor for HCB from field burning of agricultural residue is given by Hübner (2001) as 10 000 µg per ha. This factor has been converted to unit g per tonnes by following equation:

$$\mathrm{EF}_{Used} = (\mathrm{EF}_{Hubner}/Y)/1\,000\,000 \qquad \text{(Eq. 7.1)}$$

Where:

EF_{Used} = emission factor, g per tonnes
EF_{Hubner} = emission factor given by Hübner (2001), 10 000 µg per ha
Y = yield, tonnes per ha

Table 7.3 Emission factor for HCB from field burning of agricultural waste.

	Yield, tonnes per ha	EF, g per tonnes
Straw from cereals	3.4	0.003
Straw from seed production	5	0.002

8 HCB emission from use of pesticides

Hexachlorobenzene (HCB) is a poisonous substance, which is dangerous to human and animal health. HCB is used as agent in pesticides and some of the pesticides used in Denmark contain HCB, but pure HCB used as pesticide is banned.

There are two sources for HCB emission in the agricultural sector: field burning of agricultural residue and the use of pesticides. Emissions of HCB from field burning of agricultural residues are described in Chapter 7.

Table 8.1 shows the emission of HCB from use of pesticides for the years 1990-2018. The emission has decreased significantly from 1990 to 2023 due to decrease in use of pesticides containing HCB.

Table 8.1 Emission of HBC, 1990-2023, kg.

	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Pesticides	4.29	3.37	0.34	0.01	0.06	0.04	0.12	0.20	0.23	0.23

8.1 Calculation method

The emission is calculated using following equation:

$$E_{pes} = \sum a_i/1000 \cdot EF_i/1000 \qquad \text{(Eq. 8.1)}$$

Where:

E_{pes} = emission of HCB from pesticides, kg
a_i = amount of effectual substance in the pesticide i, kg
EF_i = emission factor for the pesticide i, g per tonne

8.2 Activity data

A range of pesticides are used in Denmark. In the period from 1990 to 2023 six types of pesticides containing HCB have been identified as used in Denmark. These are atrazine, chlorothalonil, clopyralid, lindane, pichloram and simazine. Data on the amounts of active substances used in Denmark are collected from the Danish Environmental Protection Agency (DEPA, 2022b), see Table 8.2. The use of atrazine and lindane stopped in 1994 and the use of chlorothalonil and simazine ceased in 2000 and 2004, respectively.

Table 8.2 Amounts of effectual substance used in Denmark, 1990-2023, kg (DEPA, 2022b).

	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Atrazine	91.294	-	-	-	-	-	-	-	-	-
Chlorothalonil	10.512	10.980	7.340	-	-	-	-	-	-	-
Clopyralid	16.461	22.587	7.446	5.874	9.122	10.229	3.102	3.396	3.130	3.130
Lindane	8.356	-	-	-	-	-	-	-	-	-
Pichloram	-	-	-	-	723	328	2.265	3.775	4.466	4.466
Simazine	30.234	19.865	23.620	-	-	-	-	-	-	-

8.3 Emission factors

Emission factors given in EMEP/EEA Guidebook (EMEP, 2023) are used in the calculation of the emissions, see Table 8.3.

Table 8.3 Emission factors for HCB from pesticides, 1990-2023, g per tonnes.

	1990	1995	2000	2005-2023
Atrazine	2.5	-	-	-
Chlorothalonil	300	300	40	-
Clopyralid	2.5	2.5	2.5	2.5
Lindane	100	-	-	-
Pichloram	-	-	-	50
Simazine	1	1	1	-

9 Non-Methane Volatile Organic Compounds

NMVOC emission originates from animal manure, manure applied to soil, grazing animals, cultivated crops and grass and field burning of agricultural residues. Agriculture accounted for 46 % of the national NMVOC emission in 2023 and is mainly related to emission from animal manure, manure applied to soil and grazing animals, which accounts for 83 %, 13 % and 4 %, respectively in 2023, while cultivated crops and field burning accounts for less than 1 %.

9.1 Manure management

NMVOC from manure is related to animal husbandry and mainly to cattle production.

9.1.1 Emission

The trend in NMVOC emission from 1985 to 2023 shows a decrease from 47 kt to 38 kt with the highest fall at the beginning of the period (Figure 9.1). The greatest part of the emission originates from cattle. Emission from dairy cattle is almost unaltered from 1985-2023 because while the number of dairy cattle has decreased the feed intake has increased. The emission from non-dairy cattle decreases due to decease in number of animals.

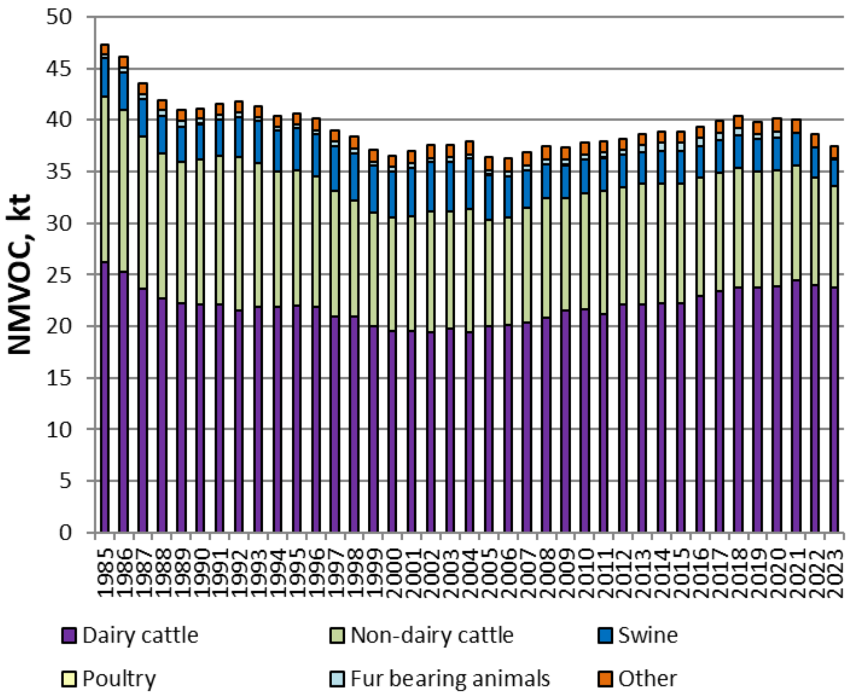

Figure 9.1 Emission of NMVOC from manure management, 1985-2023.

9.1.2 Calculation method

The estimation of NMVOC emissions is based on the EMEP/EEA guidebook (EMEP, 2023). NMVOC emissions from animal husbandry come from feed, degradation of feed in the rumen and from undigested fat, carbohydrate and protein decomposition in the rumen and in the manure. Silage is a major source of NMVOC emissions.

The calculation of NMVOC emissions is based on the Tier 2 approach. The number of animals is given as the average annual population (AAP).

$$E_{NMVOC,manure} = AAP_i \cdot (EF_{NMVOC,silage_{store}} + EF_{NMVOC,silage_{feeding}} + EF_{NMVOC,barn} + EF_{NMVOC,manure\_store}) \quad \text{(Eq. 9.1)}$$

Where:

$E_{NMVOC,\ manure}$	= emission of NMVOC from manure management, kg
AAP_i	= number of animals given in average annual population for the animal category i
$EF_{NMVOC,silage\_store}$	= emission of NMVOC from silage storage, kg per AAP_i
$EF_{NMVOC,silage\_feeding}$	= emission of NMVOC from silage feeding, kg per AAP_i
$EF_{NMVOC,\ barn}$	= emission of NMVOC from barn, kg per AAP_i
$EF_{NMVOC,manure\_store}$	= emission of NMVOC from manure storage, kg per AAP_i

$$EF_{NMVOC,silage\_store} = Z \cdot x_{house} \cdot (EF_{NMVOC,silage_{feeding}} \cdot Frac_{silage}) \cdot Frac_{silage\_store} \quad \text{(Eq. 9.2)}$$

$$EF_{NMVOC,silage_{feeding}} = Z \cdot x_{house} \cdot \left(EF_{NMVOC,silage_{feeding}} \cdot Frac_{silage}\right) \quad \text{(Eq. 9.3)}$$

$$EF_{NMVOC,barn} = Z \cdot x_{barn} \cdot EF_{NMOVC,barn} \quad \text{(Eq. 9.4)}$$

$$E_{NMVOC,manure\_store} = E_{NMVOC,barn} \cdot \left(\frac{E_{NH3,storage}}{E_{NH3,barn}}\right) \quad \text{(Eq. 9.5)}$$

Where:

Z	= for cattle; gross feed intake, MJ. For other animal categories, VS (volatile solids) excreted, kg VS per year
X_{house}	= proportion of the year the animals are in the barn
$Frac_{silage}$	= fraction of silage in the feed composition
$Frac_{silage\_store}$	= proposition of emission from silage storage, 0.25
$EF_{NMVOC,\ silage\_feeding}$	= emission factor for silage feeding, for cattle, kg NMVOC per MJ, for other animals, kg NMVOC per kg VS
$EF_{NMVOC,\ barn}$	= emission factor for barn, for cattle, kg NMVOC per MJ, for other animals, kg NMVOC per kg VS
$E_{NH3,\ barn}$	= NH_3 emission from barns, kg NH_3-N
$E_{NH3,\ storage}$	= NH_3 emission from storage, kg NH_3-N
$E_{NH3,\ appl}$	= NH_3 emission from application, kg NH_3-N

9.1.3 Activity data

The activity data for the NMVOC emission from manure management is number of animals and grazing days/days in barns, see Chapter 4, gross feed intake for cattle and VS excretion for other animal categories, see Chapter 11.

9.1.4 Emission factor

NMVOC emission factors recommended in EMEP/EEA Guidebook (EMEP, 2023), Table 3-11 and 3-12 is used (see Table 9.1).

The same emissions factors are used for all years, which means that changes of the emission over time depend on change in animal production or change in grazing days/proportion of the year the animals are in the barns.

Table 9.1 NMVOC emission factors (EMEP (2023) Tier 2).

	EF		Frac	
	Silage feeding	Barn	Silage	Silage stored
	kg NMVOC per MJ			
Dairy cattle	0.0002002	0.0000353	1	0.25
Non-dairy cattle	0.0002002	0.0000353	1	0.25
	kg NMVOC per kg VS			
Sheep	0.01076	0.001614	0.5	0.25
Swine – sows	0	0.007042	0	0.25
Swine – other	0	0.001703	0	0.25
Goats	0.01076	0.001614	0.5	0.25
Horses	0.010760	0.001614	0.5	0.25
Laying hens	0	0.005684	0	0.25
Broilers	0	0.009147	0	0.25
Turkeys	0	0.005684	0	0.25
Other poultry	0	0.005684	0	0.25
Fur bearing animals	0	0.005684	0	0.25

9.2 Animal manure applied to soil

For manure application, NMVOCs are formed in the manure during storage and released after manure application. No EFs are available to directly, and independently, estimate emissions of NMVOCs resulting from manure application. A correlation between NH_3 emissions and many of the different NMVOCs emitted from livestock barns has been found (EMEP, 2023) and therefore are NMVOC emissions from manure application estimated as a fraction of those from livestock barns.

9.2.1 Emission

NMVOC emission from manure applied to soil has decreased with 79 % from 1985 to 2023 and this is mainly due to the decrease in the ratio between emission of NH_3 from manure applied to soil and NH_3 emission from barns. The emission in 2023 amounted to 5.9 kt NMVOC, see Table 9.2.

Table 9.2 Emission of NMVOC from manure applied to soil, 1985-2023, kt NMVOC

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
NMVOC	27.5	21.3	16.3	10.2	5.8	6.2	5.4	6.1	6.2	6.0	5.9

9.2.2 Calculation method

Emission of NMVOC from manure applied to soil is based on Tier 2 method given in EMEP/EEA guidelines 2023 Chapter 3B Manure management but reported in sector 3Da2a.

$$E_{NMVOC,appl} = AAP_i \cdot EF_{NMVOC,appl} \quad \text{(Eq. 9.6)}$$

Where:

$E_{NMVOC,\,appl}$ = emission of NMVOC from manure applied to soil, kg

AAP_i = number of animals given in average annual population for the animal category i

$EF_{NMVOC,appl}$ = emission of NMVOC from manure application, kg per AAP_i

9.2.3 Activity data

The activity data for the NMVOC emission from manure applied to soil is number of animals, see Chapter 4.

9.2.4 Emission factor

The emission factor is calculated by multiplying the NMVOC emission factor for barn systems with the relative ratio between the NH_3 emission related to application of manure and NH_3 emission from barn systems, as presented below:

$$EF_{NMVOC,appl} = EF_{NMVOC,barn} \cdot (\frac{E_{NH3,appl}}{E_{NH3,barn}}) \quad \text{(Eq. 9.7)}$$

Where:
$EF_{NMVOC,\ barn}$ = emission of NMVOC from barn, kg per AAP_i
$E_{NH3,\ barn}$ = NH_3 emission from barn, kg NH_3-N
$E_{NH3,\ appl}$ = NH_3 emission from application, kg NH_3-N

The emission factor for NMVOC is estimated for each animal category and varies for all years due to changes in EF barn and the relative ratio between the NH_3 emission related to application of manure and NH_3 emission from barn systems.

9.3 Grazing animals

The emission of NMVOC from grazing animals is based on number of days the animals are on grass and for cattle gross energy for the time on grass. For other animal categories are the emission based on days on grass and manure excreted, given in volatile solids (VS).

9.3.1 Emission

The emission of NMVOC from grazing animals has decreased 68 % from 1985 to 2023 and this is mainly due to a decrease in both number of dairy cattle and decrease in number days on grass for dairy cattle.

Table 9.3 Emission of NMVOC from grazing animals, 1985-20233, kt NMVOC.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
NMVOC	0.22	0.19	0.19	0.18	0.12	0.09	0.08	0.07	0.07	0.07	0.07

9.3.2 Calculation method

Emission of NMVOC from grazing animals is based on the Tier 2 method given in EMEP/EEA guidelines 2023 Chapter 3B Manure management but reported in sector 3Da3. The NMVOC emission is estimated on the number of animals, the actual days on grass, gross energy for cattle and VS for other animal categories.

$$E_{NMVOC,graz} = AAP_i \cdot EF1_{NMVOC,graz} \quad \text{(Eq. 9.8)}$$

Where:
$E_{NMVOC,\ graz}$ = emission of NMVOC from grazing, kg

AAP_i	= number of animals given in average annual population for the animal category i
$EF1_{NMVOC, graz}$	= emission of NMVOC from manure application, kg per AAP_i

9.3.3 Activity data

The activity data for the NMVOC emission from grazing animals is number of animals and days on grass, see Chapter 4, gross feed intake for cattle and VS excretion for other animal categories, see Chapter 11.

9.3.4 Emission factor

The calculation of the emission factor per animal is estimated based on gross energy intake for cattle and VS for other animal categories multiplied by the share of the year the animals are on grass and multiplied with emission factors for grazing given in EMEP (2023), see Table 9.4.

$$EF1_{NMVOC,graz} = Z \cdot (1 - x_{house}) \cdot EF2_{NMVOC,graz} \quad \text{(Eq. 9.9)}$$

Where:

Z	= for cattle; gross feed intake, MJ. For other animal categories; VS (volatile solids) excreted, kg VS per year
X_{house}	= proportion of the year the animals are in the barn
$EF2_{NMVOC, graz}$	= emission factor for grazing, for cattle, kg NMVOC per MJ, for other animals, kg NMVOC per kg VS, see Table 9.4

Table 9.4 Emission factor for NMVOC for grazing animals (EMEP, 2023).

	EF NMVOC grazing
	Kg NMVOC per MJ feed intake
Dairy cattle	0.0000069
Non-dairy cattle	0.0000069
	Kg NMVOC per kg VS excreted
Sheep	0.00002349
Swine – sows	
Swine – other	
Goats	0.00002349
Horses	0.00002349
Laying hens	
Broilers	
Turkeys	
Other poultry	
Fur bearing animals	

9.4 Cultivated crops

Emission of NMVOC from cultivated crops may arise to attract pollinating insects, eliminate waste products or as a means of losing surplus energy (EMEP, 2023). The calculation of the NMVOC emission from cultivated crops is based on emission factors recommended in EMEP/EEA Guidebook (EMEP, 2023).

9.4.1 Emission

The NMVOC emission from cultivated crops is estimated to 1.90 kt in 2023 based on an IEF (implied emission factor) at 0.72 and a cultivated area of

2 620 947 hectares. The IEF varies annually from 0.51 - 0.82 kg NMVOC per hectare (Table 9.5) depending on the allocation of wheat, rye, rape and grass. Higher allocation of rape and rye result in higher IEF due to a higher emission factor for these two crop types.

Table 9.5 Cultivated area, IEF and emission of NMVOC.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Total cultivated area, 1000 ha	2 834	2 788	2 726	2 647	2 707	2 646	2 633	2 620	2 618	2 624	2 621
IEF, kg per ha	0.66	0.71	0.58	0.56	0.53	0.57	0.80	0.72	0.73	0.82	0.72
Emission, kt	1.87	1.99	1.57	1.48	1.42	1.51	2.11	1.90	1.91	2.16	1.90

9.4.2 Calculation method

In Table 3-4 in the EMEP/EEA Guidebook (EMEP, 2023), emission factors for cultivation of wheat, rye, rape and grass (15°C) are given. A Tier 2 IEF is estimated corresponding to Danish yield level of dry matter content (DM) for these crop types. The emission from other crop types is not available in the Guidebook. However, the total NMVOC emission is estimated as the Tier 2 IEF multiplied with the total cultivated area. See equation 9.10 and Table 9.6 for factors:

$$E_{NMVOC} = A \cdot IEF \quad \text{(Eq. 9.10)}$$

Where:

E_{NMVOC} = emission of NMVOC from agricultural soils, kg (*1* in Table 9.6)
A = total cultivated area, ha (see Table 9.5)
IEF = implied emission factor, kg per ha (*2* in Table 9.6) (see Chapter 9.4.4)

9.4.3 Activity data

Area of wheat, rye, rape and grass is used for estimating IEF. The total area of cultivated crops is used to estimate the total emission of NMVOC from cultivated crops. All areas are based on Statistics Denmark (DSt, 2024).

9.4.4 Emission factors

Here, the equations for the calculation of the IEF. See Table 9.6 for factors used.

$$IEF = \frac{\sum E_i}{\sum ha_i} \quad \text{(Eq. 9.11)}$$

Where:

IEF = implied emission factor, kg per ha (*2* in Table 9.6)
E_i = emission for the crop *i*, kg (*3* in Table 9.6)
ha_i = area of the crop *i*, ha (*4* in Table 9.6)

$$E_i = EF_i \cdot 24 \cdot 365 \cdot Frac_i \cdot DM_i \cdot ha_i \quad \text{(Eq.9.12)}$$

Where:

E_i = emission for the crop *i*, kg per ha per year (*4* in Table 9.6)
EF_i = emission factor for crop *i*, kg per kg DM per hour (*5* in Table9.6), (EMEP, 2023)
24 = hour per day
365 = days per year
$Frac_i$ = fraction of year emitting for crop *i* (*6* in Table 9.6)
DM_i = mean dry matter for crop *i*, kg DM per ha (*7* in Table 9.6)
ha_i = area for crop *i*, ha (*4* in Table 9.6)

Table 9.6 Estimation of NMVOC emission factor, 2023.

	EF_i [5]	$Frac_i$ [6]	DM_i [7]	Cultivated area[4]	NMVOC emission[3]	IEF[2] – Tier 2 DK
Crop	Kg NMVOC/ kg DM/year		kg DM/ha	ha	Kg/ha/year	kg NMVOC/ha
Wheat	2.60E-08	0.3	6 333	481 072	207 753	
Rye	1.41E-07	0.3	4 760	107 602	189 587	
Rape	2.02E-07	0.3	3 589	211 664	402 464	
Grass land*	1.03E-08	0.5	5 894	479 415	127 485	
Total				1 279 753	927 290[1]	0.72

*Grass land 15 °C

[1-7] see Eq. 9.10-9.12

10 Nitrogen oxides

Emission of nitrogen oxides (NO_x), reported in NO_2 equivalents, includes emission from manure management and agricultural soils. The emission from agricultural soil includes emission from nitrogen applied to soil as animal manure, inorganic N fertiliser, grazing animals, sewage sludge and other organic fertiliser. The agricultural sector accounted for 21 % of the total NO_x emission in 2023 and the main part occurs from animal manure applied to soil and inorganic N fertiliser.

10.1 Manure management

NO_x emission from manure management relates to the emissions from barns and account for around 4 % of the agricultural emission of NO_x in 2023.

10.1.1 Emission

The NO_x emission from 1985 to 2023 decreased significantly from 1.0 kt NO_x to 0.7 kt NO_x corresponding to a 29 % reduction. The emission depends on number of animals given as the average annual population (AAP) and manure type, and the decrease is mainly related to changes from solid based systems to slurry-based systems for both dairy cattle and swine production. Thus, the share of solid manure was 24 % in 1985 and dropped to 11 % in 2023. The increase in 2009 is mainly due to increase in AAP for broilers, which according to Statistics Denmark (DSt, 2024) increased from 9.7 million in 2008 to 14.8 million in 2009.

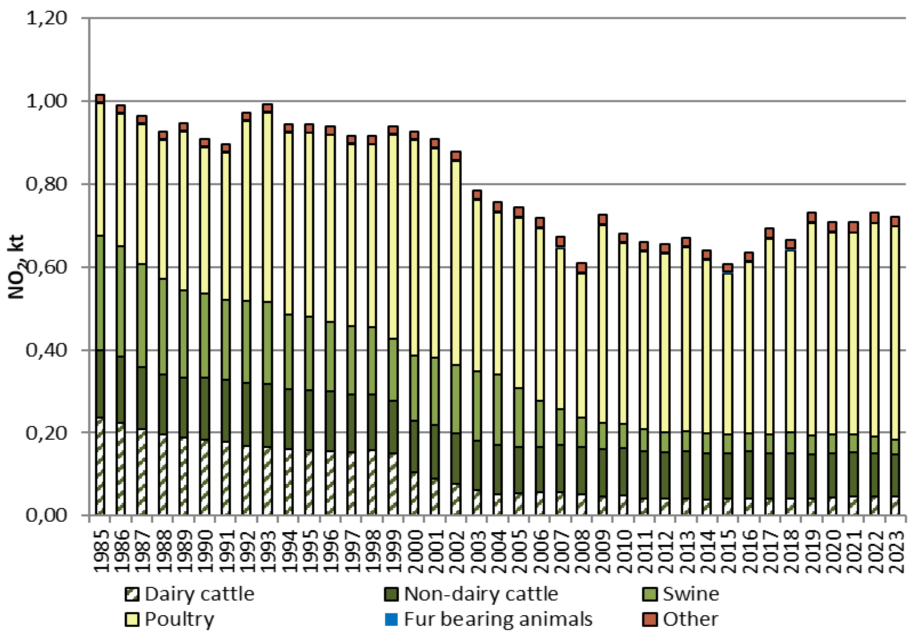

Figure 10.1 NO_2 emission from manure management 1985–2023.

10.1.2 Calculation method

The estimation of NO_x emission is based on the EMEP/EEA guidebook (EMEP, 2023) Tier 1 and is based on number of animals given as the average annual population (AAP).

$$E_{NO_x} = AAP_i \cdot EF_i \quad \text{(Eq. 10.1)}$$

Where:

E_{NO2} = emission of NO_x, kg
AAP_i = average annual population of animal category i
EF_i = emission factor for animal category i, kg per AAP

10.1.3 Activity data

The emission calculations are based on number of animals and barn/manure type (See Chapter 4).

10.1.4 Emission factor

Emission factor for estimation of NO_x emission from manure management is listed in Table 10.1. Some of the manure from the mink production is handled as slurry, but no EF for slurry is mentioned in the Guidebook. Therefore, the same emissions factor is used for both slurry and solid systems.

Table 10.1 NO_x emission factors (EMEP, 2023), kg NO_x per AAP.

NFR code	Livestock	Slurry	Solid
3B1a	Dairy cattle	0.01	0.752
3B1b	Other cattle	0.003	0.217
3B2	Sheep		0.012
3B3	Sows	0.005	0.471
3B3	Fattening pigs	0.002	0.017
3B4d	Goats		0.012
3B4e	Horses		0.25
3B4gi	Laying hens	0.014	0.0001
3B4gii	Broilers		0.027
3B4giii	Turkeys		0.027
3B4giv	Ducks		0.022
3B4giv	Geese		0.005
3B4h	Fur bearing animals[1]	0.001[2]	0.001

[1] EMEP (2023) EF for other animals.

[2] Used the same EF as given for solid manure.

10.2 Agricultural soils

Emission of NO_x from manure applied on soils, inorganic N fertiliser, grazing animals, sewage sludge and other organic fertiliser is estimated and accounts for 42 %, 47 %, 4 %, 1 % and 1 %, respectively, of the agricultural emission of NO_x.

10.2.1 Emission

The main part of the NO_x emission from agricultural soils comes from manure applied to soil and use of inorganic N fertiliser. The emission has decreased from 1985 to 2023 by 39 % mainly due to decrease in use of inorganic N fertiliser.

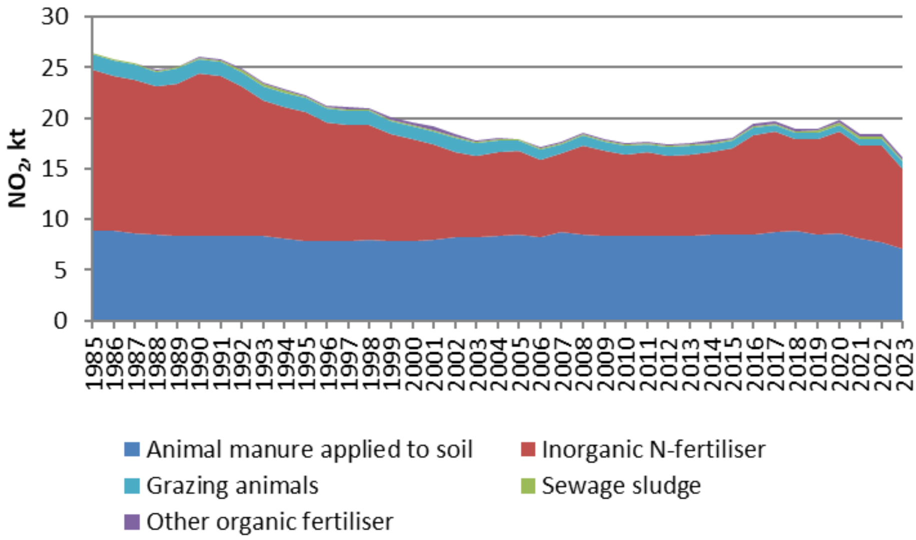

Figure 10.2 NO_x emission from agricultural soils, 1985-2023.

10.2.2 Calculation method

The emission of NO_x is calculated based on the following equation:

$$E_{NO_x} = \sum N_i \cdot EF \qquad \text{(Eq. 10.2)}$$

Where:

E_{NOx} = emission of NO_x, kg NO_2 equivalents
N_i = amount N applied from *i* fertiliser type, kg
EF = emission factor, 0.04 kg NO_x per kg N applied

10.2.3 Activity data

The amount of N applied from manure applied and from grazing animals are based on the normative standards, see Chapter 5.1.3. For inorganic fertiliser the amount of N is based on sales statistics and farmers fertiliser accounts, see Chapter 5.2. For sewage sludge the amount of N is based on information from the Danish Environmental Protection Agency (DEPA), see Chapter 5.4. Other organic fertiliser includes emission from industrial wastes, which is sludge from industries, and ‘other biomass’ includes digestate from other types of biomasses aside from manure treated in biogas plants, both applied to agricultural soils as fertilizer, see Chapter 5.5.

10.2.4 Emission factor

The emission factor for NO_x is the default value from the EMEP/EEA guidebook (EMEP, 2023), which recommends an emission factor of 0.04 kg NO_2 per kg N applied. The background reference is based on a literature study, which does not distinguish between different kinds of fertiliser types. The default emission factor is used for manure applied on soils, inorganic N fertiliser, grazing animals, sewage sludge and other organic fertiliser.

11 Methane

A major part of the agricultural methane (CH_4) emission originates from the digestive processes (enteric fermentation), but emissions also take place from manure management and field burning. The agricultural CH_4 emissions accounted for 80 % of the total CH_4 emission in 2023. The digestive processes in ruminants, predominantly cattle, are the largest source of agricultural CH_4 emissions. The emission from manure is due to the bacterial breakdown under anaerobic conditions (primarily in slurry). The field burning of agricultural residues is also included as a source of emissions but contributes less than 1 % to total agricultural emissions of CH_4, see Chapter 7 for information for field burning of agricultural residues.

For the CH_4 emission from manure management, a lower emission from biogas treatment of slurry is taken into account, which is described in Chapter 11.2.

The methodology used to calculate the CH_4 emission is based on guidance given in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019) for emission from enteric fermentation and emission from solid manure. Emission from slurry from cattle and swine and biogas treated slurry are estimated based on a national Tier 3 method, see Chapter 11.2.

11.1 Enteric fermentation

The CH_4 emission from enteric fermentation can be regarded as an energy loss under the digestion process. It is mainly ruminants that produce CH_4, whereas monogastric animals – e.g. swine, horses, poultry and fur animals – produce CH_4 to a much smaller degree.

The emission is primarily from cattle, which, in 2023, contributed 88 % of the emission from enteric fermentation. The emission from swine production is the second largest source at 8 % and the rest of the animals; horses, sheep, goats, poultry and deer make up the remaining 4 %. The relative contribution from swine production has increased over the years as a result of a production expansion as well as a reduction in the number of cattle.

From 1990 to 2023, the emission from enteric fermentation has overall decreased by 11 %, which is primarily related to a decrease in the number of cattle. The number of swine has increased from 9.5 million in 1990 to 10.5 million in 2023, but this increase is only of minor importance for the total CH_4 emission from enteric fermentation. The emission was lowest in 2005 but increased slightly until 2023, mainly due to a slight increase in emission from cattle which is due to increase in feed intake.

11.1.1 Emissions

The main part of the emission of CH_4 from enteric fermentation comes from cattle. The development in milk production has been a high increase in milk per cow, which has increased the feed per cow and thereby increased the implied emission factor. Due to fixing the total production of milk by the EU milk quota, the number of dairy cattle has decreased. The EU milk quota ended in 2015, and the total milk production has increased, but due to higher feed efficiency, the IEF and emission is almost unaltered. The emission of CH_4 from enteric fermentation from dairy cattle has decreased from 1990 to 2007 and increased from 2008 to 2023.

The emission from non-dairy cattle decreases from 1990 to 2005 and from 2006 to 2023 the emission is almost unaltered.

Emission from swine increases slightly due to increase in number of animals.

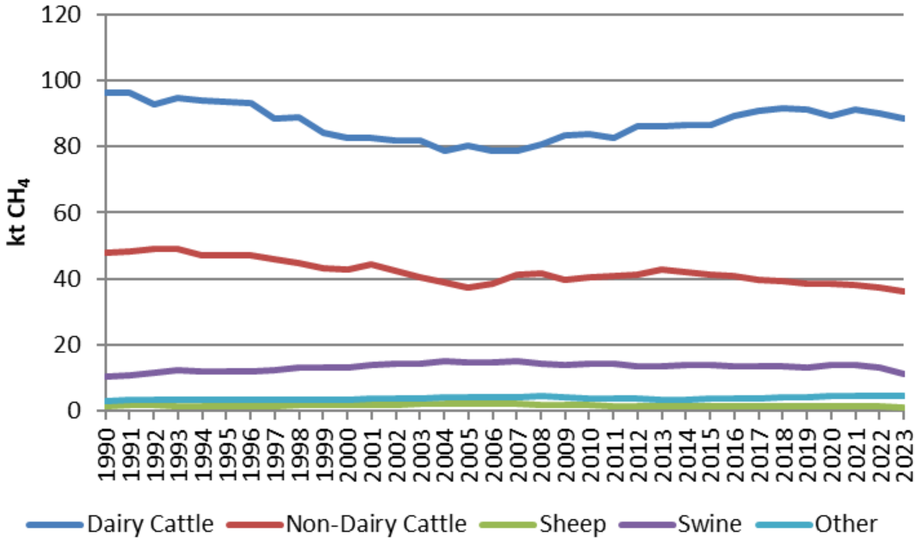

Figure 11.1 Emission of CH_4 from enteric fermentation, 1990-2023. For all numbers see Appendix X.

11.1.2 Calculation method

The calculation of CH_4 production from the digestive system is based on the animal's total gross energy intake (GE) and the CH_4 conversion factor, which is the fraction of gross energy in feed converted to CH_4, see Equation 11.1.

$$EF_{CH4} = \frac{GE \cdot Y_m \cdot 365}{55.65} \quad \text{(Eq. 11.1)}$$

Where:

EF_{CH4}	= emission factor of CH_4, kg per head per year
GE	= gross energy intake, MJ per head per day (national data)
Y_m	= methane conversion rate, % of gross energy in feed converted to methane
55.65	= conversion factor, from MJ to kg CH_4 (IPCC, 2019)

For the conversion of MJ to kg CH_4, the value recommended by the IPCC is used. The CH_4 conversion rate Y_m is the extent to which feed energy is converted to CH_4 and varies depending on the breed of animal and the respective feeding strategy. Y_m for dairy cattle are based on a national value, while Y_m for other animal categories are based on IPCC and literature, see Chapter 11.1.5.

The difference between summer and winter feed intake is taken into account. Feed intake in summer is based on feed plans with mainly grass whereas winter feed plans are based on roughage and concentrates.

$$CH_{4\ enteric,total} = CH_{4\ enteric,winter} + CH_{4\ enteric,summer} \quad \text{(Eq. 11.2)}$$

11.1.3 Emission calculation for poultry and fur animals – Tier 1

For fur animals, poultry, ostrich and pheasants, data on gross energy are not available in the IPCC Guidelines. Based on country specific information (Hansen, 2010, Pers. Comm.) CH_4 emission from enteric fermentation from fur animals is considered not applicable.

The emission calculation for poultry, ostrich and pheasants is calculated by a Tier 1 methodology:

$$\mathrm{CH}_{4,\ \mathrm{enteric}} = \sum \mathrm{EF}_i \cdot \mathrm{No.}_i \quad \text{(Eq. 11.3)}$$

Where:

$CH_{4,\ enteric}$ = emission of CH_4
EF_i = emission factor for animal category i, CH_4 per animal
$No._i$ = number of animals, category i

Emission factors used for poultry, ostrich and pheasants are based on the emission factors given by Wang & Huang (2005) (see Table 11.1). EF for broilers with a life cycle of 30-56 days is scaled in proportion to 42 days for broilers given by Wang & Huang (2005). Organic broilers with a life cycle of 81 days are scaled in proportion to the Taiwan country chicken with 91 days of life cycle and pullets with a life cycle of 112-119 days is scaled in proportion to the 140 days given for pullets by Wang & Huang (2005). EF for ducks, geese, turkeys, ostrich chicken and pheasant chicken are scaled by weight in proportion to a broiler with 40 days of life cycle. For laying hens, the EF given by Wang & Huang (2005) is used and for ostrich hens and pheasant hens, the EFs are scaled by weight in proportion to a laying hen.

Table 11.1 Emission factors for poultry in mg CH_4 per head per lifecycle.

	CH_4 emission factor
Broilers, 42 days	15.87
Taiwan country chicken, 91 days	84.82
Pullets, 140 days	3 561
Laying hens, 365 days	10 610

11.1.4 Emission calculation for cattle, swine, sheep, goats and horses by Tier 2

The calculation of CH_4 from enteric fermentation for animals other than poultry and fur animals is calculated using a method based on IPCC 2019 Tier 2.

The Tier 2/country specific (CS) equation for EF of enteric fermentation is the sum of the feeding situation in winter and summer. EF is based on actual feeding plans, which is provided from data for feed units (FU) in the feed for each livestock category. Except from dairy cattle and bulls (from 2022), where the EF is based on kg dry matter (DM) in the feed. For dairy cattle, feeding with beets is taken into account, because beet feeding gives a higher methane production rate compared to grass and maize due to the high content of easily convertible sugar. Feeding with beets is only relevant for dairy cattle, therefore the equation below concerning beet will be left out for the remaining animal categories.

$$EF = EF_{winter} + EF_{summer} \quad \text{(Eq. 11.4)}$$

Dairy cattle:

$$EF_{winter,\ dairy\ cattle} = F \cdot \quad \text{(Eq. 11.5)}$$

$$\Big(\ (GE_{F\ winter}/55.65) \cdot Y_{m\ excl\ beet} \cdot (1 - grazing\ days/365 - days\ with\ beet/365)$$

$$+ (GE_{F\ winter}/55.65) \cdot Y_{m\ incl\ beet} \cdot days\ with\ beet/365\ \Big)$$

$$EF_{summer,\ dairy\ cattle} = F \cdot \left(\frac{GE_{F\ summer}}{55.65}\right) \cdot Y_{m\ grazing} \cdot \frac{grazing\ days}{365} \quad \text{(Eq. 11.6)}$$

Where:

EF_{winter}	= Emission factor for winter feed, kg CH_4 per head per year
EF_{summer}	= Emission factor for summer feed, kg CH_4 per head per year
F	= feed, kg DM
$GE_{F,\ winter}$	= gross energy per kg DM, MJ per kg DM in winter
$GE_{F,\ summer}$	= gross energy per kg DM, MJ per kg DM in summer
Y_m	= methane conversion rate, % of gross energy in feed converted to methane
Grazing days	= feeding days on grass, days
55.56	= energy content of CH_4, MJ per CH_4

Bulls from 2022 (before 2022 calculated as for other animals):

$$EF = F \cdot \left(\frac{GE_F}{55.65}\right) \cdot Y_m$$

Where:

EF	= Emission factor, kg CH_4 per head per year
F	= feed, kg DM
GE_F	= gross energy per kg DM, MJ per kg DM
Y_m	= methane conversion factor, per cent of gross energy in feed converted to methane
55.65	= energy content of CH_4, MJ per CH_4

Other animals:

$$EF_{winter} = FU \cdot \left(\left(\frac{GE_{FUwinter}}{55.65}\right) \cdot Y_m \cdot \left(1 - \frac{grazing\ days}{365}\right)\right) \quad \text{(Eq. 11.7)}$$

$$EF_{summer} = FU \cdot \left(\frac{GE_{FU\ summer}}{55.65}\right) \cdot Y_{m\ grazing} \cdot \frac{grazing\ days}{365} \quad \text{(Eq. 11.8)}$$

Where:

EF_{winter}	= Emission factor for winter feed, kg CH_4 per head per year
EF_{summer}	= Emission factor for summer feed, kg CH_4 per head per year
FU	= feeding units
$GE_{FU, winter}$	= gross energy per feeding unit, MJ per FU in winter
$GE_{FU, summer}$	= gross energy per feeding unit, MJ per FU in summer
Y_m	= methane conversion rate, % of gross energy in feed converted to methane
Grazing days	= feeding days on grass, days
55.56	= energy content of CH_4, MJ per CH_4

Thus, to calculate the total gross energy (GE) intake, the estimation of GE per kg DM or GE per feed unit – defined as GF_F or GE_{FU}, respectively is needed. A feed unit in Denmark is defined as the feed value in 1.00 kg barley with a dry matter content of 85 % (DSt, 2010). For other cereals, e.g. wheat and rye one feed unit is 0.97 kg and 1.05 kg, respectively.

11.1.5 Gross energy intake (GE)

GE_F for dairy cattle are estimated by SEGES (Aaes, 2016, Pers. Comm.) and GF_F for bulls (from 2022) are estimated by DCA (Hellwing, 2023, pers. comm.). From 2014 feed intake for dairy cattle given in the normative standards are provided in kg DM per year and the energy in the feed is provided in MJ per kg DM. The energy intake is a standard winter feed regardless of whether the animal grazes or not. As recommended by previous expert review teams, the feed intake and energy in the feed for the years 1990-2013 is recalculated. Previous the calculation was based on FU for the years 1990-2013, which is now replaced by the calculation based on DM for all years. See Appendix V for time series for GE for dairy cattle.

For all livestock categories other than dairy cattle and bulls from 2022, the estimation of GE (GE_{FU}) is based on the composition of feed intake and the energy content in proteins, fats and carbohydrates based on actual efficacy feeding controls or actual feeding plans at farm level, collected by SEGES or DCA. The data are provided in Danish feed units or kg feedstuff, and these values are converted to mega joule (MJ). The calculation is shown in the equations below:

$$GE_{FU} = \frac{MJ/day}{FU/day} \quad \text{(Eq. 11.9a)}$$

$$FU/day = \frac{kg\ DM}{day} \cdot \frac{FU}{kg\ DM} \quad \text{(Eq. 11.9b)}$$

$$MJ/day = \frac{kg\ DM}{day} \cdot \frac{MJ}{kg\ DM} \quad \text{(Eq. 11.9c)}$$

$$MJ/kg\ DM = \%_{crude\ protein} \cdot E_{crude\ protein} + \%_{crude\ fat} \cdot E_{crude\ fat} + \%_{carbohydrates} \cdot E_{carbohydrates} \quad \text{(Eq. 11.9d)}$$

$$\%_{carbohydrates} = 100 - (\%_{crude\ protein} + \%_{crude\ fat} + \%_{raw\ ashes}) \quad \text{(Eq. 11.9e)}$$

Where:

GE_{FU}	= gross energy per feed unit, MJ per FU
FU	= feed unit

MJ = mega joule
DM = dry matter
$\%_{crude\ protein}$ = share of crude protein in the feed, %
$E_{crude\ protein}$ = energy factor for crude protein, MJ per kg DM (Table 11.2)
$\%_{raw\ fat}$ = share of crude fat in the feed, %
$E_{raw\ fat}$ = energy factor for crude fat, MJ per kg DM (Table 11.2)
$\%_{carbohydrates}$ = share of carbohydrates in the feed, %
$E_{carbohydrates}$ = energy factor for carbohydrates, MJ per kg DM (Table 11.2)
$\%_{raw\ ashes}$ = share of raw ashes in the feed, %

Table 11.2 Energy factors used for GE.

	MJ per kg DM	
	Cattle, horses, sheep and goats[1]	Swine[2]
$E_{Crude\ protein}$	24.2	23.7
$E_{Raw\ fat}$	34.1	38.9
$E_{Carbonhydrates}$	17.3	17.5

[1] Weisbjerg & Hvelplund (1992)

[2] Poulsen (2002)

For horses, heifers, suckling cows, sheep and goats an average winter feed plan is provided (Andersen, 2003, Pers. Comm.; Clausen, 2004, Pers. Comm. Bligaard, 2004, Pers. Comm.; Holmenlund, 2004, Pers. Comm.), on which the calculation of GE content is based (See Appendix W). Gross energy for deer is based on feed plans for goats, as their feeding conditions resemble those of deer the most.

11.1.6 CH_4 conversion rate (Y_m)

For dairy cattle, investigations from DCA have shown a change in fodder practice over the years where among others change in fodder practice from use of sugar beet to maize (whole cereal) is seen. Sugar beet feeding gives a higher methane production rate compared to grass and maize due to the high content of easily convertible sugar.

The estimation of the national values of Y_m is for the years 1990-2002 based on the model "Karoline" developed by DCA and based on average feeding plans for 20 % of all dairy cows in Denmark obtained from SEGES (Olesen et al., 2005). DCA have estimated the CH_4 emission for a winter-feeding plan for two years, 1991 (Y_m=6.7) and 2002 (Y_m=6.0). Y_m for the years between 1991 and 2002 is estimated by interpolation. Sugar beets are only included in the winter-feeding plan and the Y_m is therefore also adjusted for days on winter and summer feeding plan. It is assumed that winter feeding plan covers 200 days. See Table 11.3a.

New measurements (Hellwing et al., 2016) have developed an updated model for estimating a national Y_m. Based on this updated model and fodder practice were rations with sugar beet are phased out, the Y_m value for dairy cattle are kept at 6.00 from 2002 to 2017 (Lund, pers. comm., 2014). See Table 11.3b.

For 2018, 2020 and 2021 the updated model have been run with updated fodder practice and Y_m has been estimated for large breed and Jersey cows, respectively (Lund et al., 2020, Lund et al., 2021, Lund et al., 2023) – see Table 11.3c. Y_m for 2019 are kept at the same level as for 2018 and Y_m for 2022-2023 are kept at the same level as for 2021.

Table 11.3a CH_4 conversion rate (Y_m) 1990-2001, based on model Karoline, fodder practice with sugar beet, %

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Y_m incl. sugar beet	6.7	6.7	6.6	6.6	6.5	6.4	6.4	6.3	6.3	6.2	6.1	6.1
Y_m excl. sugar beet	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Y_m grazing	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Average Y_m	6.4	6.4	6.3	6.3	6.3	6.2	6.2	6.2	6.1	6.1	6.1	6.0

Table 11.3b CH_4 conversion rate (Y_m) 2002-2017, based on updated model, fodder practice without sugar beet, %

	2002-2017
Y_m winter	6.0
Y_m grazing	6.0
Average Y_m	6.0

Table 11.3c CH_4 conversion rate (Y_m) 2018-2023, based on updated model, Y_m for large breed and Jersey cows, %

	2018	2019	2020	2021	2022	2023
Y_m winter						
- Large breed	5.94	5.94	5.76	5.77	5.77	5.77
- Jersey	5.92	5.92	5.80	5.81	5.81	5.81
Y_m grazing	6.00	6.00	6.00	6.00	6.00	6.00
Average Y_m	5.94	5.94	5.78	5.79	5.79	5.79

For non-dairy cattle, sheep and goats, Y_m given in IPCC (2019) are used. For lamb, a Y_m is given in IPCC (2006). For swine and horses, Y_m are based on Crutzen et al. (1986).

Table 11.4 CH_4 conversion rate (Y_m) for non-dairy cattle, swine, sheep, goats and horses, %.

	Y_m
Bulls and bull calves	3.00
Heifers, heifer calves and suckling cows	6.30
Swine	0.60
Sheep	6.70
Lamb	4.50
Goats	5.50
Horses	2.50

11.1.7 Important variables and implied emission factors for 2023

An overview of the most important variables and the implied emission factor (IEF) for 2023 is shown in Table 11.5. A distinction is made between animals where emissions are calculated based on an annual average population (AAP) (see Table 11.5a) and animals where the emission is based on one produced animal (see Table 11.5b).

Table 11.5a Feed consumption and conversion rates to determine the CH_4 emission from livestock enteric fermentation, values per AAP[a], 2023.

Livestock category	Feed intake	Gross energy (GE)		Feed on grass	Y_m	IEF[b]
		Winter	Summer			
	FU per year	MJ per FU		% feeding days per year	% of gross energy	kg CH_4 per AAP[a]
Cattle (large breed):						
Dairy cattle	8 488[c]	18.90[d]	18.90	5	5.77	166.70
Heifer calves, < ½ year	1 047	18.30	18.83	-	6.3	21.69
Breeding calves, ½ year to calving	2 094	25.75	18.83	13	6.3	58.53
Suckling cows > 600 kg	2 502	34.02	18.83	50	6.3	69.96
Swine[e]:						
Sows incl. piglets < 6.6 kg	1 513	17.49	17.49	-	0.6	2.85
Other:						
Horses, 600 kg	2 555	29.83	18.83	50	2.5	27.93
Sheep incl. lambs	498	29.95	18.83	59	6.7	13.12
Lambs	153	29.95	18.83	59	4.5	2.71
Goats for meat production incl. kids	667	29.95	18.83	59	5.5	14.42
Deer	668	30.00	18.83	100	5.5	12.43
	kg feed	MJ per kg feed				
Barn hens (100 unit)	4 310	17.46	17.46	-	-	1.06
Mink incl. young	257	11.47	11.47	-	-	0

[a] AAP - annual average population (See definition in Section 4.1).
[b] IEF – implied emission factor.
[c] kg dry matter.
[d] See Appendix V for the time series.
[e] Conventional production.

Table 11.5b Feed consumption and conversion factors to determine the CH_4 emission from livestock enteric fermentation, values per produced animal, 2023.

Livestock category	Feed intake	Gross energy (BE)		Feed on grass	Y_m	IEF[a]
		Winter	Summer			
	FU	MJ per FU		%	% of gross energy	kg CH_4 per prod. animal
Cattle (large breed):						
Bulls calves, < ½ year	578[b]	19.00	18.83	-	3	5.92
Bulls, ½ year to slaughter, 410 kg	889[b]	19.00	18.83	-	3	9.11
Swine[c]:						
Weaners, 6.4-31 kg	43	16.46	16.46	-	0.6	0.08
Fattening pigs, > 31 kg	218	17.25	17.25	-	0.6	0.40
	kg feed	MJ per kg feed				
Broilers, 35 days (1 000 unit)	3340	18.99	18.99	-	-	0.01
Ostriches	-	-	-	-	-	0.66
Pheasants (100 unit)	-	-	-	100	-	0.47
Geese (100 unit)	2800	18.19	18.19	100	-	0.005
Turkeys, cock/hen (100 unit)	5070/2430	18.55	18.55	-	-	0.01
Ducks (100 unit)	975	18.19	18.19	-	-	0.003

[a] IEF – implied emission factor.
[b] kg dry matter.
[c] Conventional production.

11.2 Manure management

CH_4 emission from animal manure is calculated based on the energy in animal manure, taking into account barn conditions as manure type and use of straw for bedding. The barn type determines the manure type and the CH_4 production varies depending on the manure type. Anaerobic conditions, as for example found in slurry, promote CH_4 formation.

For manure management the estimation of the CH_4 emission is based on a Tier 3 methodology for emission from slurry/liquid manure from cattle, conventional produced swine and digestate and IPCC Tier 2 methodology for all other combinations of animal/manure types. The Tier 2 calculation is based on manure excretion instead of feed intake as described in 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019). Default values for maximum methane producing capacity (B_0) and MCF given by the IPCC are used. The calculation of volatile solids (VS) is based on national data, see Chapter 11.2.2. For description of Tier 2 and Tier3 calculation methodology see Chapter 11.2.3 and 11.2.4, respectively.

11.2.1 Emissions

Emission of CH_4 from manure management contributes with 28 % of the total GHG from the agricultural sector in 2023. A major part of the emission originates from the production of cattle (52 %) followed by swine production (46 %). The remaining part is mainly from horses (2 %).

The overall CH_4 emission from manure management increased by 5 % from 1990 to 2023 but the main increase is seen from 1990-2004. From 2005-2023, the emission decreases and especially in 2022 and 2023, which is mainly due to emissions from swine.

The emission from swine has increased from 1990 to 2004 and hereafter decreased until 2023 and particularly from 2021-2023. The emission is mainly determined by the production of fattening pigs, and the emission development follows the same trend as the number of produced fattening pigs but also due to change to more slurry-based barn systems and decreases again due to change to barn systems with a shorter storage time (HRT - Hydraulic Retention Time) for the manure in the barns. From 2023, the farmers are obliged to frequently remove the slurry from the barns for fattening pigs, which decreases the emission. Also, increased amount of slurry being treated in biogas plans decreases the emission.

The emission from dairy cattle increased from 1990 to 2018, despite a decrease in number of dairy cattle, but is related to higher milk yield and thus higher feed intake and higher manure excretion. From 2019-2023, the emission decreases mainly due to increased amount of slurry being treated in biogas plans.

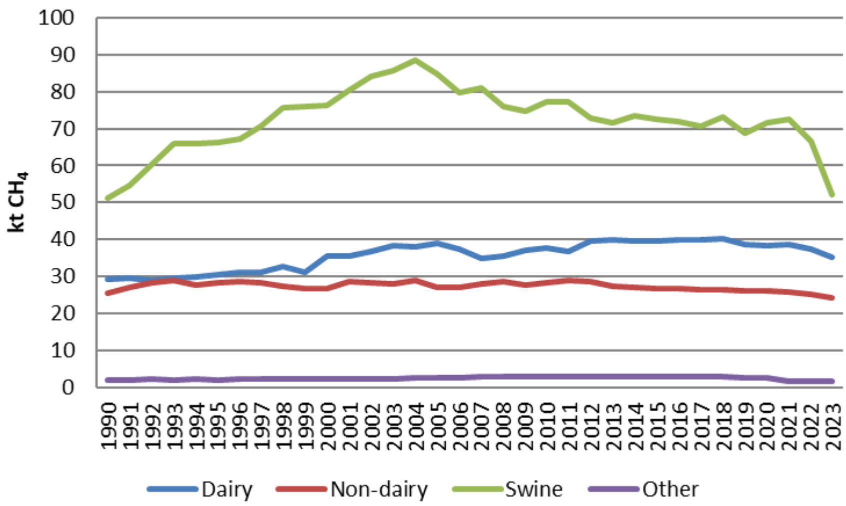

Figure 11.2 CH_4 emission from manure management, 1990 - 2023. For all numbers see Appendix Y.

11.2.2 Estimation of volatile solids (VS)

VS is calculated from data concerning amount of manure, dry matter content, share of VS in dry matter, amount of bedding and grazing days. Except for grazing days for dairy cattle and heifers, all these parameters are based on the Danish Manure Normative Standards (Børsting et al., 2021). Grazing days for dairy cattle and heifers are based on estimations made by SEGES Innovation (Martinussen, 2022). The determination of VS is country-specific, given that it is based on the amount of manure excreted.

$$VS_{barn} = \frac{m}{365} \cdot DM_M \cdot VS_{DM} \cdot (365 - g_1) + s \cdot DM_s \cdot \left(1 - \frac{\%\,ash}{100}\right) \cdot (365 - g_2) \quad \text{(Eq. 11.10)}$$

$$VS_{grazing} = \frac{m}{365} \cdot DM_M \cdot VS_{DM} \cdot g_1 \quad \text{(Eq. 11.11)}$$

Where:
VS = volatile solids, kg per animal per year
m = amount of manure excreted, kg per animal per year
DM = dry matter of M manure or S straw, %
VS_{DM} = volatile solids of dry matter, %
g_1 = feeding days on grass, days per year [1]
g_2 = actual days on grass, days per year
s = amount of straw, kg per animal per year
% ash = ash content in straw

The ash content in straw is set to 4.5 % (SEGES, 2005). VS of dry matter is 80 % for all livestock categories (Sommer et al., 2008, Sommer et al., 2013). The number of days on grass are based on information from DCA and SEGES (Poulsen et al., 2001, Clausen 2008, Børsting et al., 2021, Martinussen, 2022) and is shown in Appendix H. The amount of manure excreted, and straw used, depends on barn type and is given in the normative standards table (Børsting & Hellwing, 2024).

[1] Actual days on grass are the number of days that animal is outside. Feeding days on grass is higher than actual days on grass due to a higher feed intake (intake of N) during grazing compared to the period in barns. Feeding days on grass is a conversion of this higher feed intake on grass.

The VS daily excretion for the livestock categories in average is shown in Appendix Z.

11.2.3 Tier 2 methodology

The IPCC Tier 2 methodology is used for all other combinations of animal/manure types than slurry/liquid manure from cattle, conventionally produced swine and digestate.

The amount of manure and VS is calculated for each combination of livestock subcategory and barn type and then aggregated to the IPCC livestock categories. In the calculation, grazing days and use of straw in the barn are taken into account. Equation for CH_4 calculation:

$$CH_{4,manure} = EF\ CH_{4,barn} \cdot n_{animals} + EF\ CH_{4,grazing} \cdot n_{animals} \qquad \text{(Eq. 11.12)}$$

Where:

$n_{animals}$ = number of animals

$$EF\ CH_{4,barn} = VS_{barn} \cdot MCF \cdot 0.67 \cdot B_0 \qquad \text{(Eq. 11.13)}$$

$$EF\ CH_{4,grazing} = VS_{grazing} \cdot MCF \cdot 0.67 \cdot B_{0grazing} \qquad \text{(Eq. 11.14)}$$

Where:

VS_{barn} = calculated by equation 11.10

MCF = methane conversion factor given by IPCC (2006 and 2019)

B_0 = maximum methane producing capacity given by IPCC (2019) (Table 11.6)

0.67 = conversion factor of m^3 CH_4 to kilograms $_{CH4}$

Table 11.6 Maximum methane producing capacity (B_0), m^3 CH_4 per kg VS.

	B_0	B_0 grazing
Dairy cattle	0.24	0.19
Non-dairy cattle	0.18	0.19
Swine	0.45	0.19
Sheep	0.19	0.19
Goats	0.18	0.19
Deer	0.18	0.19
Fur bearing animals	0.25	-
Horses	0.3	0.19
Hens	0.39	0.19
Broilers, turkeys, ducks and geese	0.36	0.19
Ostriches	0.25	0.19

MCF - Methane conversion factor used in Tier 2 methodology

Emissions calculated by Tier 2 are based on default values provided in the IPCC guidelines for MCF. For liquid systems for fur bearing animals and organic swine, the MCF is a weighted value depended on the situation for covered and uncovered slurry tanks in Denmark. Also, for swine on deep bedding barn system is used a weighted value due to the residence time of manure in the barn.

MCF – Slurry/liquid manure

For liquid systems for fur bearing animals and organic swine, the MCF is a weighted value depended on the situation for covered and uncovered slurry tanks in Denmark. Due to legislation from 2003, all slurry tanks must be fully covered or have established a floating cover. However, it is difficult to achieve full floating cover all days of the year, and some emissions can take place during filling and mixing of manure in the tank. Therefore, it is assumed that floating/fixed covers are absent 2 % of the time. This results in a weighted MCF of 98 % covered slurry (MCF=10 (IPCC, 2006)) and 2 % uncovered (MCF=17 (IPCC, 2006)), which gives a MCF of 10.1 in 2023 for fur animals and organic swine slurry.

Table 11.7 Methane conversion factor (MCF) used in Tier 2 calculations for slurry/liquid manure in 2023, %.

	2023
Fur bearing animals	10.14
Organic swine	10.14
Poultry	1.5

MCF - Deep bedding and solid manure

Default values provided in the IPCC guidelines for MCF are used in the Tier 2 calculations for deep bedding and solid manure. For swine, the MCF for deep bedding depends on how long the manure is stored in the barn, and the emission is particularly higher for bedding stored more than one month. The bedding situation is based on information from SEGES and is different for the three swine subcategories. The lowest MCF at 8.2 % is seen for weaners because 70 % of the bedding material is removed during the first month. The situation is opposite for sows where only 20 % of the bedding is removed during the first month, which leads to a higher MCF at 18.0 %, see Table 11.8.

Table 11.8 MCF factor for swine, deep bedding.

		DK condition, % of year		MCF - IPCC, 2006	
MCF, swine deep bedding	MCF, DK	> 1 month	< 1 month	> 1 month	< 1 month
Deep bedding weaners	8.23 %	30	70	21 %	2.75 %
Deep bedding fattening	13.70 %	60	40	21 %	2.75 %
Deep bedding sows	17.96 %	80	20	21 %	2.75 %

Table 5.16 are shown MCF used for deep bedding and solid manure for other animal types than swine. MCF used for deep bedding and solid manure are the same for all years 1990-2023.

Table 11.9 Methane conversion factor (MCF) used in Tier 2 calculations for solid manure and deep litter, %.

	All years
Cattle	
Solid manure	2
Deep litter > 1 month	21
Deep litter < 1 month	2.75
Poultry	
With and without litter	1.5
Sheep, goats and horses	
Solid manure	2
Fur bearing animals	
Solid manure	2
Deep litter	2.75
All animal types outdoor/grazing	0.47

11.2.4 Tier 3 methodology

The emission of CH_4 from cattle slurry, slurry from conventionally produced swine and anaerobically digested biomass/primarily animal manure (digestate) is calculated by a national Tier 3 model. The calculations are based on VS and EF based on the temperature dependent CH_4 formation functions (Van't-Hoof/Arrhenius equation) (Sommer et al., 2004). The emission calculation also taking into account the HRT - Hydraulic Retention Time, which is the average time slurry is stored in a barn system before being discharged to an outside storage tank or transported to a biogas plant. Emissions are divided into emission from barns (cattle and swine) and emission from storage (cattle, swine, digestate).

Emission from barns is calculated as:

$$E_{barn} = VS_{barn} \cdot (EF_{barn}/365) \cdot HRT \qquad \text{(Eq. 11.15)}$$

Where:
E_{barn} = emission of CH_4 from barns, kg CH_4 per year
VS_{barn} = volatile solids, kg VS per year, based on VS excreted
EF_{barn} = emission factor for CH_4, g CH_4 per kg VS per year, based on measurements see Table 11.10
365 = number of days per year
HRT = Hydraulic Retention Time, days, see Table 11.13

And emission from storage is calculated as:

$$E_{Storage} = VS_{storage} \cdot EF_{storage} \qquad \text{(Eq. 11.16)}$$

Where:
$E_{storage}$ = emission of CH_4 from storage slurry, kg CH_4
$VS_{storage}$ = volatile solids, divided in degradable and non-degradable VS
$EF_{storage}$ = emission factor for CH_4, divided into degradable and non-degradable, see Table 11.10

In Table 11.10 is listed the estimated emission factor for barns, storage and digested slurry, given in CH_4 emission per VS excreted.

Table 11.10 Estimated emission factors.

Cattle	g CH_4 per kg VS per year
EF_{barns}	175.49
$EFd_{storage}$	72.83
$EFnd_{storage}$	0.72
Swine	
EF_{barns}	549.83
$EFd_{storage}$	93.17
$EFnd_{storage}$	0.92
Digested	
$EFd_{storage, digested}$	2.67*
$EFnd_{storage, digested}$	0.03

* From Submission 2026 this will be corrected to 3.42 g CH_4 per kg VS per year

The model

The overall methodology for estimating the CH_4 emission from liquid animal manure and digestate is as mentioned based on the available amount of volatile substance (VS) in the biomass and the temperature dependent CH_4

formation functions (Van't-Hoof/Arrhenius equation) (Sommer et al., 2004). The model by Sommer et al. (2004) uses a 2-pooled concept for estimating the CH_4 emission from degradable VS (VSd) and from non-degradable VS (VSnd). To take into account a "decreasing" emission due to depletion of the VS in the manure in up to 8-9 months a degradation model has been developed.

The CH_4 emission factor in barns for swine is estimated to 549.83 g CH_4 per kg VS per year, based under the assumption that the average temperature is 18.6 °C. VS from barns is not divided into VSd and VSnd because the measured emission relates to the total amount of VS.

For cattle barns, the temperature varies throughout the year. The emission factor of 175.49 g CH_4 per kg VS per year is an average for a year. The period in which the cattle is on grass gives less manure in the barns and this is taken into account through amount of VS.

Methane emission from outdoor storage of not digested slurry is estimated in a matrix, where slurry is supplied and taken away with a time step of 10 days. The matrix sums the total methane emission until the decomposition of VS is almost null (around two years). The amount of VS supplied the storage is the total VS excretion from the animals and the straw used for bedding, subtracted VS-loss from barns. Removal of VSd and VSnd from storage is estimated for every time step and a new methane emission is calculated. For cattle slurry the estimation gives an emission of 73.55 g CH_4 per kg VS (VSd plus VSnd) and for swine slurry the estimation gives 94.09 g CH_4 per kg VS (VSd plus VSnd).

For estimation of methane emission from outdoor storage of digested slurry, the amount of digested slurry delivered to the biogas plants based on the BIB register is used (see Chapter 11.2.5). Same model as used for not digested slurry is used for digested slurry, though with a higher temperature in the storage after biogas treatment. The stored digested slurry has a high content of VSnd and the emission of methane is therefore low. The CH_4 emission factor from digested slurry is estimated to 2.70[2] g CH_4 per kg VS (VSd plus VSnd).

The coming chapters will describe in more detail the assumptions and data used for calculation for the CH_4 emissions factors.

Estimation of VSd and VSnd in storage

Estimation of VS_{barn} is shown in Chapter 11.2.2 Equation 11.10. Estimation of VSd and VSnd in storage are estimated as:

$$VSd_{storage} = VS_{barns} \cdot w - (VS_{barns} \cdot w \cdot x \cdot HRT) \qquad \text{(Eq. 11.17)}$$

Where:

VS_{barns}	= volatile solids, kg VS per year, based on VS excreted
w	= degradable VS, kg VSd per kg VS, see Table 11.11
x	= VSd lost, kg VSd per HRT day, see Table 11.11
HRT	= Hydraulic Retention Time, days, see Table 11.13

[2] From Submission 2026, this will be corrected to 3.45 g CH_4 per kg VS per year.

$$\mathrm{VSnd}_{\mathrm{storage}} = \mathrm{VS}_{\mathrm{barns}} \cdot \mathrm{y} - (\mathrm{VS}_{\mathrm{barns}} \cdot \mathrm{y} \cdot \mathrm{z} \cdot \mathrm{HRT}) \quad \text{(Eq. 11.18)}$$

Where:
VS_{barns} = volatile solids, kg VS per year, based on VS excreted
y = non-degradable VS, kg VSnd per kg VS, see Table 11.11
z = amount of VSnd lost, kg VSnd per HRT day, see Tabel 11.11
HRT = Hydraulic Retention Time, days, see Table 11.13

Table 11.11 Factors for VS calculation.

Cattle	Unit	
w	kg VSd per kg VS	0.33[a]
x	kg VSd per HRT day	0.0028
y	kg VSnd per kg VS	0.67[a]
z	kg VSnd per HRT	0.000058
Swine		
w	kg VSd per kg VS	0.51[a]
x	kg VSd per HRT day	0.0101
y	kg VSnd per kg VS	0.49[a]
z	kg VSnd per HRT	0.000097

[a] Petersen et al (2016)

Parameters for Arrhenius function

The parameters for Arrhenius function are based on Petersen et al. (2016), Elsgaard et al. (2016) and Maldaner et al. (2018). Equation 11.19 shows the calculation of CH_4 emission from slurry F(T), VSd and VSnd are the proportions of degradable and "non-degradable" VS. The ln$A$ is the pre-exponential factor (≈ methane production potential) and Ea the activation energy of methanogenesis, while R is the universal gas constant and T is the absolute temperature.

$$\mathrm{F(T)} = \left(\mathrm{VS_d} * \mathrm{b_1} * \exp\left(\ln\mathrm{A} - \mathrm{E_a} * \left(\frac{1}{\mathrm{RT}}\right)\right) + \mathrm{VS_{nd}} * \mathrm{b_2} * \exp\left(\ln\mathrm{A} - \mathrm{E_a} * \left(\frac{1}{\mathrm{RT}}\right)\right)\right) \cdot 24 \quad \text{(Eq. 11.19)}$$

Where:
F(T) = the methane production rate, g CH_4 per day
VSd = the proportions of degradable volatile solids, kg
VSnd = the proportions of non-degradable volatile solids, kg
b1 and b2 = scaling factors, 1 for VSd and 0.01 for VSnd (dimension-less)
lnA = the pre-exponential factor (≈ methane production potential), g CH_4 per kg VS per h
Ea = the activation energy of methanogenesis, J per mol
R = the gas constant, 8.314 J per mol per K
T = temperature, K
24 = conversion from hour to day

Ea: An activation energy, Ea, of 81 kJ per mol was proposed by Elsgaard et al. (2016) which represented the temperature response of a cattle slurry, a swine slurry, fresh digestate and stored digestate (no significant differences).

LnA: The parameter lnA reflects a potential for CH_4 production that is influenced by the chemical and biological characteristics of the slurry, which in Petersen et al. (2016) is derived for 20 samples of swine slurry and 11 samples cattle slurry. In average the observed lnA was 31.3 and 31.2 g CH_4 kg-1 VS h-1 for pig and cattle slurry, respectively. For digestate the observed lnA was 27.9 g CH_4 kg-1 VS h-1.

VS – volatile solid: The amount of excreted dry matter is taken from the Danish Normative Standards for animal manure (data included in IDA). The share of VS of dry matter is set as a default to 80 % as used in agricultural inventories (Sommer et al., 2008, Sommer et al., 2013).

VSd and VSnd: In the model for estimating the CH_4 emission a 2-pooled model is used, dividing the VS in VSd and VSnd (Tong et al., 1990, Sommer et al., 2004). The share of VSd and VSnd has for the purpose of the inventories been estimated by Petersen et al. (2016) for swine (sow, weaners and fattening pigs) and cattle slurry (mainly dairy cattle slurry). The manure samples were taken in barns in full production and can thus be seen as normal farming practise. Petersen et al. (2016) estimated the average age of the swine slurry to 13-15 days and the cattle slurry to around 20-30 days. The slurry samples can therefore be seen as quite fresh manure with only little degradation.

Petersen et al. (2016) sampled 20 swine slurry samples and 11 dairy cattle slurry samples and estimated the VSd. For swine manure they found an average VSd of 51 % (95 % Confidence Interval: 44 – 57 %) and for slurry for dairy cattle a VSd of 33 % (95 % Confidence Interval: 29 – 37 %).

Møller and Moset (2015) has measured dry matter and VS in digested manure from eight biogas plants. They found an average dry matter in the digested manure of 4.88 % were VS of dry matter in average were 3.32 %. Møller (2016) has measured the B0-value of the digestate from the continuous biogas plants to 13.8 m^3 CH4 per kg VS indicating that a major part of the digestate is non-degradable.

In Table 11.12 is shown the used parameters.

Table 11.12 CH_4 emission estimate parameters. Petersen et al. (2016) combined with Elsgaard et al. (2016) and Maldaner et al. (2018).

	Ea, kJ per mol	Ln(A), g CH_4 per kg VS per hour	VSd, %	VSnd, %
Liquid cattle manure	81	31.2	33	67
Liquid swine manure	81	31.3	51	49
Digestate	81	27.9	100[a]	0

[a]For digestate, the model parameter is set to 100 mimicking that all VS is degradable.

Degradation function

Based on literature data and unpublished research data it was estimated that the C loss from manure stores constitutes roughly of 20 % CH_4-C and 80 % CO_2-C (Dinuccion et al., 2008). In the emission estimate a conservative figure of 25 % is used. Beside this Patni and Jui (1987) found 10-25 % losses of dry matter during storage of dairy cattle slurry supporting that a high share of loss of VS is taken place as CO_2 as this is not lost as CH_4. For effluent from digested animal manure, Wang et al. (2016) found very low CH_4/CO_2 ratios at around 3-4 % (unpublished data received from Yue Wang). For the digestate, an estimate for CH_4-C/CO_2-C fraction of 10 % is used (Dong, 2013, Pers. Comm.).

The CH_4/degradation model was built in an excel spreadsheet with a time step of 10 days.

Danish barn systems and Hydraulic Retention Time (HRT)

Barn systems change over time. For cattle there was a high share of tied-up dairy cattle with liquid handling and frequent removal of the slurry in the

1990s, these were later replaced by cubicles combined with slats and in recent years cubicles with scrapers became more common. This affects time the manure is stored. The most common barn system for swine has until recently been fully slatted floors. A ban on fully slatted floors forced the farmers to build partly slatted floors/drained floors. This has reduced the storage capacity below the slats and affects time swine slurry is stored.

The average storage time is named the Hydraulic Retention Time (HRT). HRT is the average time slurry is stored in a barn system before being discharged to an outside storage tank or transported to a biogas plant. For the purpose of the Danish inventories, Kai (2024) has estimated the HRT for all barn types for cattle and swine with liquid manure mentioned in the Danish Normative Standards, see Table 11.13.

The HRTs were calculated as follows: 1) first the total amount of slurry ex barn was calculated by adding volumes of manure excreted with bedding and water waste, 2) then the daily increase in slurry level was calculated based on the calculated slurry production per day per animal and the estimated slurry surface area per animal place in the livestock barn system, 3) the average slurry level was estimated taking into account the slurry level at the time of discharge and the residual slurry after discharge, and finally 4) the HRT was calculated (Kai, 2024).

In the emission estimate, it is assumed that all manure, regardless of whether it is used for anaerobic digestion or not, has the same HRT. There are no available data that prove farms delivering manure to anaerobic digestion are emptying their slurry channels more frequently than farmers who are not.

By law (BEK, 2023) Danish farmers with fattening pigs must have frequent removal of slurry from the barns from 1 May 2023. This lowers the HRT, see Table 11.13b. In 2023 the HRT for fattening pigs is estimated as 1/3 HRT before frequent removal and 2/3 after.

Table 11.13a Hydraulic Retention Time (HRT) (Kai, 2024) for cattle, sows and weaners.

Livestock categories	Barn type	HRT, days
Dairy cattle	Tethered with urine and solid manure	1
	Tethered with slurry	4
	Loose-housing with cubicles, solid floor	1
	Loose-housing with cubicles, slatted floor	36
	Loose-housing with cubicles, slatted floor, scrape	2
	Loose-housing with cubicles, drained floor	1
	Loose-housing with cubicles, solid floor with tilt	1
	Deep litter, long eating space, solid floor	1
	Deep litter, long eating space, slatted floor, slurry channels	32
	Deep litter, long eating space, slatted floor, scraper	1
Heifer, 6 mth-calving	Slatted floor-boxes	93
	Tethered with urine and solid manure	1
	Tethered with slurry	17
	Loose-housing with cubicles, solid floor	2
	Loose-housing with cubicles, slatted floor	88
	Loose-housing with cubicles, slatted floor, scrape	2
	Loose-housing with cubicles, solid floor with tilt	2
	Deep litter, long eating space, solid floor	2
	Deep litter, long eating space, slatted floor, slurry channels	111
	Deep litter, long eating space, slatted floor, scraper	2
Bulls, 6 mth - 440 kg	Slatted floor-boxes	124
	Tethered with urine and solid manure	1
	Tethered with slurry	22
	Loose-housing with cubicles, solid floor	3
	Loose-housing with cubicles, slatted floor	126
	Loose-housing with cubicles, slatted floor, scrape	3
	Loose-housing with cubicles, solid floor with tilt	3
	Deep litter, long eating space, solid floor	2
	Deep litter, long eating space, slatted floor, slurry channels	111
	Deep litter, long eating space, slatted floor, scraper	2
Suckling cows	Tethered with urine and solid manure	1
	Tethered with slurry	15
	Loose-housing with cubicles, slatted floor	135
	Loose-housing with cubicles, slatted floor, scrape	3
	Loose-housing with cubicles, solid floor with tilt	3
	Deep litter, long eating space, solid floor	3
	Deep litter, long eating space, slatted floor, slurry channels	166
	Deep litter, long eating space, slatted floor, scraper	3
Sows, gestation period	Group-housing, deep litter + solid floor	2
	Group-housing, deep litter + slatted floor	19
	Group-housing, partly slatted floor	13
	Individual housing, partly slatted floor	23
	Individual housing, fully slatted floor	36
	Individual housing, solid floor	1

Continued		
Sows, farrow period	Individual housing, partly slatted floor	23
	Individual housing, fully slatted floor	28
	Group-housing, solid floor	1
	Group-housing, partly slatted floor	13
Weaners	Fully slatted floor	36
	Partly slatted floor	36
	Solid floor	1
	Two-climate housings, partly slatted floor	16
	Partly slatted and drained floor	36

Table 11.13b Hydraulic Retention Time (HRT) (Kai, 2024) for fattening pigs.

Fattening pigs		Before 1 May 2023	From 1 May 2023	2023*
	Fully slatted floor	20	NO	NO
	Partly slatted floor	15	NO	NO
	Partly slatted floor (50-75 % solid floor)	9	6	7
	Partly slatted floor (25-49 % solid floor)	15	7	10
	Solid floor	1	1	1
	Partly slatted floor and partly deep litter	11	6	8
	Partly slatted and drained floor	20	9	12

NO – not occurring.

* Estimated as 1/3 HRT before frequent removal and 2/3 after.

Temperatures

In the following text estimation of temperatures for swine and cattle slurry in the barns and outdoor storage is described.

Insulated swine barns

Only few measured slurry temperatures inside the barns can be found in the literature. However, SEGES (Holm, 2015) has provided results from 48 measurements in barns with fattening pigs, made at different times of the year. Based on these measurements an average slurry temperature of 18.6 °C (16.0-21.8 °C) is found, with a standard deviation of 1.29. The highest temperatures were measured in summer. When the average outdoor temperature was 16-17 °C the slurry temperature tended to be around 19 °C. In winter when the average outdoor temperature was around 2-5 °C the slurry temperature was 17-18 °C. Another study Petersen et al. (2016) has measured slurry temperatures in 27 different swine barns in November and December 2014 in connection with the CH_4 emission parameterization and found an average temperature of 18.7 °C. The results from these two studies do not vary significantly from each other. The average temperature in swine barns of 18.6 °C based on the study from Holm et al. (2015), with the highest number of measurements, are used for calculation of the CH_4 emission from swine barns.

Open cattle barns

Most cattle barns in Denmark are naturally ventilated. Inside the barns the air temperature is generally 5-6 °C higher than the outdoor temperature. In Figure 11.3 is shown result of temperature measurements of slurry inside the slurry channels, based on a study from 2017 and 2018 (Andersen and Grønkjær, 2020). Temperature measurements were carried out in two cattle barns: one in the Southern Denmark and the other one in the Northern Denmark, with logging 2-5 times per day. These temperature measurements are combined and converted to a sinewave representing the slurry temperature for Danish cattle barns (Figure 11.3).

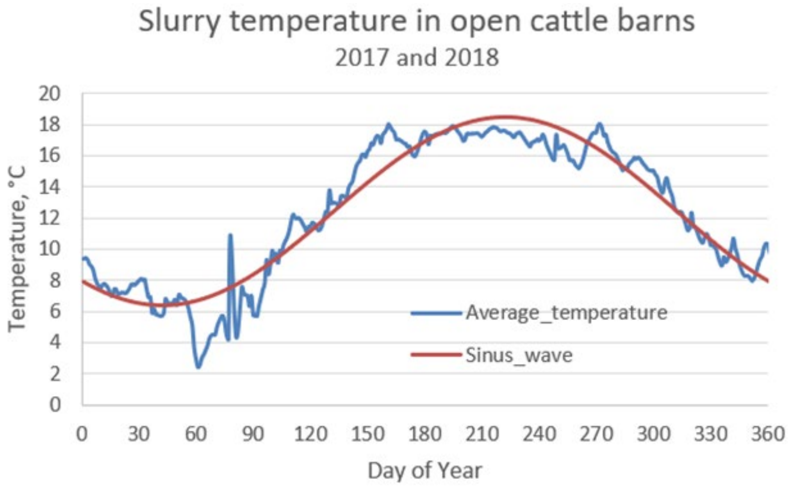

Figure 11.3 Average daily measured slurry temperature in two cattle barns in 2017 and 2018 (Andersen and Grønkjær, 2020).

Table 11.14 shows the given parameters for the Sine-function, which estimates the daily average slurry temperatures.

Table 11.14 Parameters for the Sine-function (y=a+ b sin (2πx/d+c)) for slurry temperature.

R^2 = 0.92					
Parameter	Value	Std Error	t-value	95% confidence limits	
a	12.45	0.087	142.64	12.28	12.62
b	6.04	0.098	61.55	5.84	6.23
c	3.97	0.046	86.73	3.89	4.07
d	360.08	4.209	85.55	351.80	368.35

Outdoor storage temperatures

Temperature in outdoor storage of slurry are based on data from two projects where temperature was measured in slurry tanks in Denmark (Vechi et al., 2023, Kasper & Holm, 2024). These have been combined and converted to a sinewave representing cattle slurry, swine slurry and digestate, respectively.

Vechi et al. (2023) measured temperature in ten manure storage tanks. The dataset included two tanks storing dairy cattle manure, six holding swine manure, and two with digestate from manure-based biogas plants. For each storage the temperature was measured a number of times over a year. In the further data process the average temperature per month for cattle slurry, swine slurry and digestate were estimated.

Kasper & Holm (2024) measured temperature in 16 manure storage tanks. The dataset included four tanks storing dairy cattle manure, six holding swine manure, two with acidified swine manure, and four with digestate from manure-based biogas plants. Four of them (two cattle and two swine) were measurements in the surface, so these were left out of further data processing. Temperatures in swine manure and acidified swine manure were compared and found almost identical and therefore acidified swine manure is considered swine manure in the further data processing. Average temperature per month were estimated for cattle slurry, swine slurry and digestate, respectively.

The monthly data from the two projects were combined by making averages for cattle slurry, swine slurry and digestate, respectively, and converted to a sinewave. Table 11.15 a-c shows the parameters for the Sine-functions, which estimates the daily average slurry temperatures for stored cattle slurry, swine slurry and digestate.

Table 11.15a Parameters for the Sine-function (y=a+ b sin (2πx/d+c)) for temperature for stored cattle slurry.

R^2 = 0.92					
Parameter	Value	Std Error	t-value	95% confidence limits	
a	12.33	0.155	179.70	12.01	12.66
b	5.12	0.205	25.06	4.69	5.55
c	3.84	0.092	41.78	3.65	4.04
d	363.43	4.342	83.71	354.30	372.56

Table 11.15b Parameters for the Sine-function (y=a+ b sin (2πx/d+c)) for temperature for stored swine slurry.

R^2 = 0.92					
Parameter	Value	Std Error	t-value	95% confidence limits	
a	12.58	0.071	177.99	12.44	12.73
b	6.80	0.098	69.70	6.60	7.00
c	3.93	0.031	126.86	3.87	4.00
d	365.24	0.938	389.39	363.34	367.14

Table 11.15d Parameters for the Sine-function (y=a+ b sin (2πx/d+c)) for temperature for stored digestate.

R^2 = 0.92					
Parameter	Value	Std Error	t-value	95% confidence limits	
a	16.60	0.331	50.13	15.93	17.28
b	6.22	0.462	16.47	5.28	7.16
c	3.78	0.157	24.09	3.46	4.10
d	363.80	5.043	72.13	353.53	374.08

Manure storage and application to fields

The Ministry of Environment and Food of Denmark regulate the storage time and the secondary field application of raw biomass and digested biomass. The general rule is that manure is only allowed to be applied to crops, which have a nitrogen norm and is harvested the same calendar year. Only crops with an official nitrogen norm are allowed to be fertilised.

It means that autumn application is not allowed as these crops are not harvested within the calendar year. The storage manure capacity is therefore 8-10 months including eventually storage capacity inside the barns.

Field application of manure is not allowed before 1 February and not on frozen or snow-covered areas. Because of difficulties for driving in the fields the optimum application time is March and April, plus some application to grass cuttings during summer. Data from the farmers registration and planning tool MarkOnline are by SEGES (Birkmose, 2020) used to estimate the share of manure applied for each month of the year. These data are used to estimate the fraction of annual manure production there are stored in the for each month of the year. A general average storage profile for animal manure storages is shown in Figure 11.4. The figure shows that the maximum storage is in February and the minimum in May. Slurry is generally stored in four-meter-deep concrete tanks where two meters are above ground and two meters below ground. As it is not possible to empty the tanks completely (crust cover) it is assumed that around 8 % of the annual production is the minimum amount stored in May.

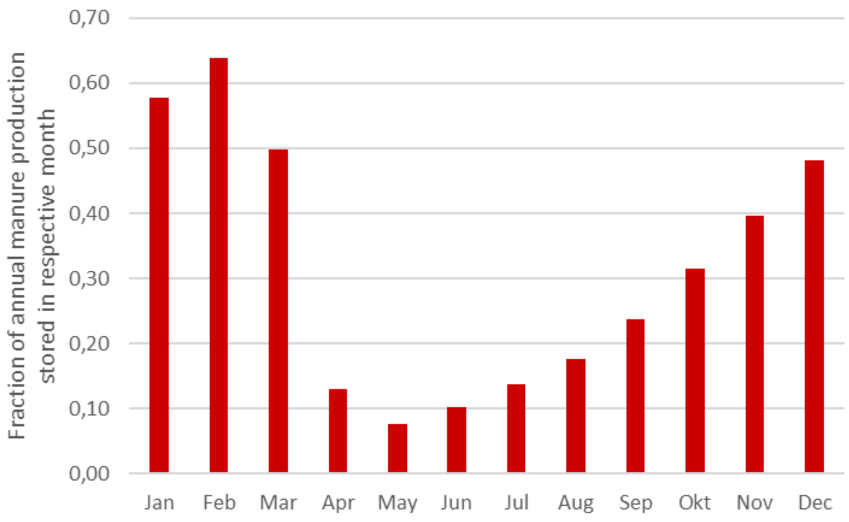

Figure 11.4 The average fraction of animal manure stored during different months of the year.

11.2.5 Biogas treatment of slurry

A significant and growing part of the Danish animal slurry is being used for production of biogas. The production uses anaerobic digestion of animal manure in combination with other biodegradable products, e.g. agricultural waste and slaughterhouse waste. Biogas treatment is important to include in the inventory, because the anaerobic digested slurry produces lower CH_4 and N_2O emission from storage.

Estimation of slurry treated in biogas plants in Denmark

In Denmark, the biogas plants are divided in five facility types: wastewater, industrial, landfills, large-scale plants (centralised multi farms) and farm-level plants. Large-scale biogas plants are larger facilities, where slurry is received from several farms and farm-level plants are characterised by receiving manure from one or a few farms. For 2023, the Energy Statistics estimated the total energy production based on biogas to 31 637 TJ (DEA, 2024a), and out of this, the manure-based biogas plants account for 92 %. The Energy Statistic provides data annually and thus data from all years 1990-2023 is available.

Table 11.16 Biogas production, 2023 (DEA, 2024a).

Facility type	Biogas production, TJ	%
Wastewater treatment	1 194	4
Industrial	1 250	4
Large-scale and farm-scale	29 078	92
Other	217	<1
Total	31 639	100

The livestock production mainly takes place in the western parts of Denmark in Jutland and consequently the majority of manure-based biogas plants are located here.

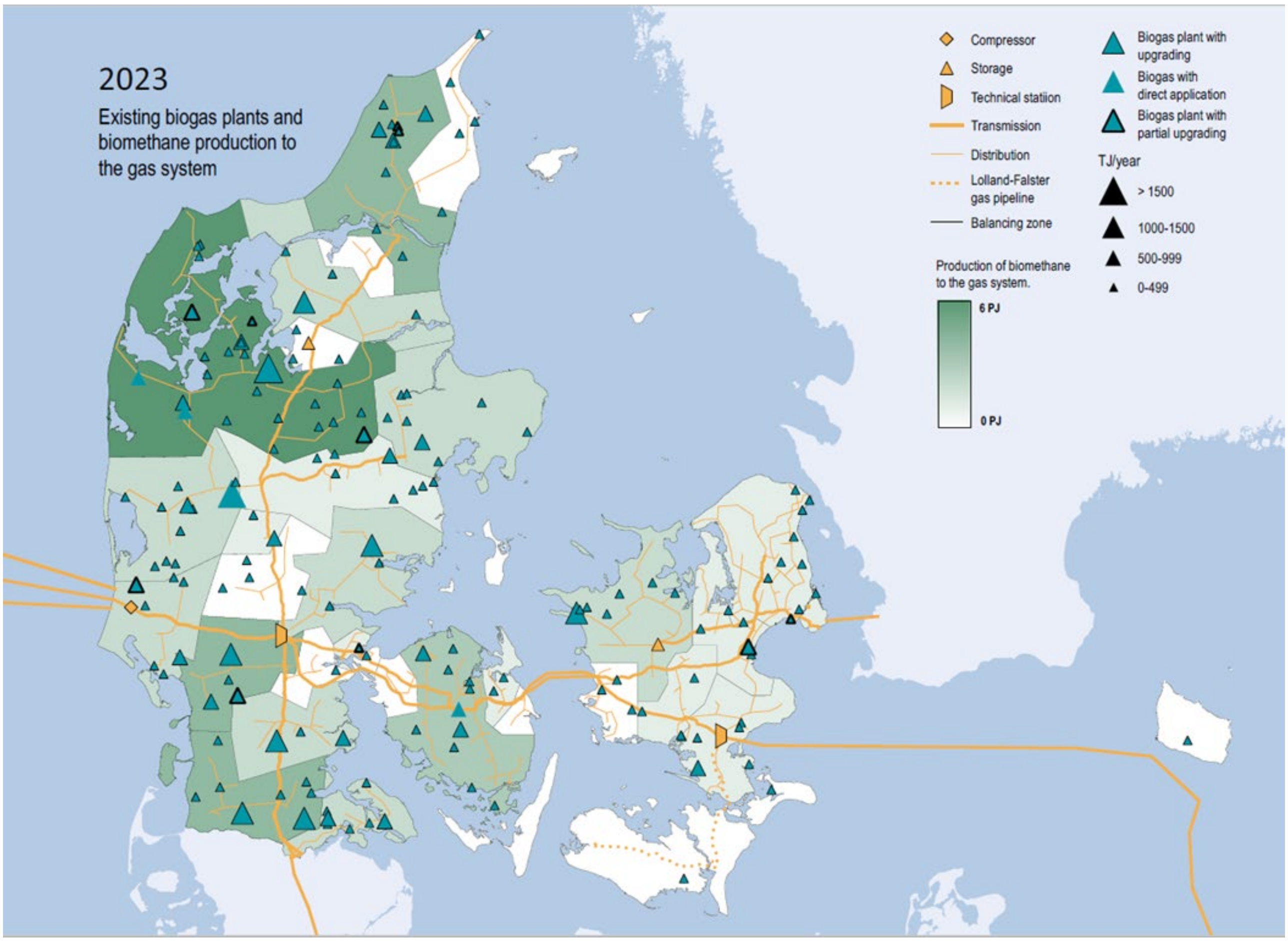

Figure 3D-2 Biogas producers in Denmark (DEA, 2023).

For the years 2015-2023, data for the actual amount and different types of biomasses delivered to the biogas plants is available. Data is collected by the Danish Energy Agency (DEA, 2024b), based on reporting from biogas plant and in the following, these data are referenced as the BIB register (Biomass Input to Biogas production). The BIB register does not fully cover all biogas plants, but the most important biogas producers, and thus it covers the majority of the total biogas production.

Data regarding the amount of slurry delivered to biogas plants is available for the years 2001, 2003, 2015-2023. Data for year 2001 and 2003 is based on a single investigation provided by the DEA – the Danish Energy Agency, while the data for years 2015-2023 is based on the BIB register. For the intervening years, 1990-2000, 2002 and 2004-2014, the data for amount of slurry delivered to the biogas production is based on an interpolation, by using the relation between the amount of slurry delivered and the total energy production produced at the biogas plants. The total energy production from biogas plants for all years is based on the Energy Statistics (DEA, 2024a).

In 1990, the biogas production at the large-scale, farm-level and industrial biogas plants is 266 TJ, which corresponds to slurry input of 220 kt, increasing to 30 328 TJ and 12 299 kt slurry in 2023.

In 2023, around 36 % of total amount of slurry is delivered to biogas production, 46 % of the total amount of cattle slurry and 26 % for swine slurry.

Table 11.17 Biogas production, 1990-2023.

	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Biogas production, TJ[1]										
Total	752	1 758	2 912	3 830	4 337	6 285	21 152	26 166	28 948	31 739
Biogas plants*	266	746	1 442	2 375	3 184	5 199	19 937	24 787	27 475	30 328
Slurry delivered to biogas plants, kt[2]										
Cattle, swine and mixed	220	617	1 192	1 838	2 115	2 884	8 303	9 575	9 981	12 299
Percent of total produced slurry	1	2	4	6	6	7	21	25	27	36

* Large-scale, farm-level and industrial.
[1]DEA, (2024a).
[2]DEA, (2024b).

The anaerobic digestion process is sensitive to several factors, such as different biomass types and different combinations of biomass input, nutrients concentration, species and concentration of bacteria, operational conditions for each biogas plant, etc. Uses of current data from the BIB register will to some extent take these variations from biogas plant into account, because the data is based on existing production management.

12 Nitrous oxide

The agricultural nitrous oxide (N_2O) emissions accounts for 88 % of the total Danish N_2O emission in 2023. The emission of N_2O comes from a range of different sources as showed in Figure 12.1. The major sources originate from application of animal manure and inorganic N fertilisers on soil and from crop residues. The calculation of N_2O emission from field burning of agricultural crop residues, which contributes less than 1 % to total agricultural N_2O emissions, is described in Chapter 7.

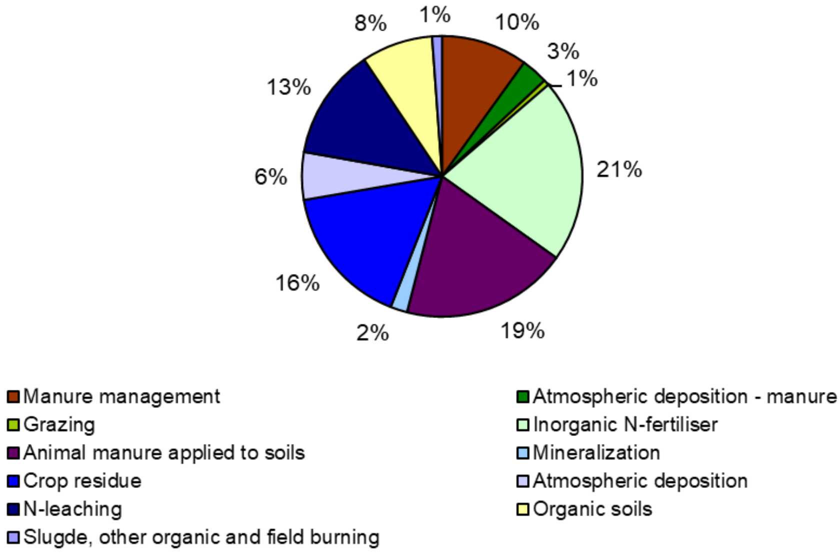

Figure 12.1 Distribution of the N_2O emission in 2023 on sources.

The methodology used to calculate the N_2O emission is based on guidance given in the 2019 IPCC Refinement (IPCC, 2019). The following chapters provide a more detailed description of the methodologies and emission factors used. The emission sources are divided into three main categories. The first covers the emission from the management of manure. The second category is direct N_2O emissions from managed soils, which covers emission from the N sources related to cultivation of agricultural soils. The last one covers indirect N_2O emissions from managed soils, which are atmospheric deposition of nitrogen volatilised from agricultural inputs and emission from nitrogen leaching and runoff.

12.1 Manure management

Emission of N_2O from manure management comes from a direct emission from the handling of the manure in barn and during storage and an indirect emission (atmospheric deposition) from the emission of NH_3 and NO_x from manure management.

12.1.1 Emissions

The N_2O emission from manure management is estimated to be 1.9 kt in 2023 of which only 0.5 is related to the indirect emission. The overall emission has decreased with 1.5 kt N_2O from 1985 – 2023 corresponding to 44 %. This decrease is mainly caused by a decreased emission from swine, which is driven by improvement of feed efficiency. The average N ex per swine has decreased dramatically from 1990 due to the farmers' economic benefit of increased feed efficiency and due to environmental requirements.

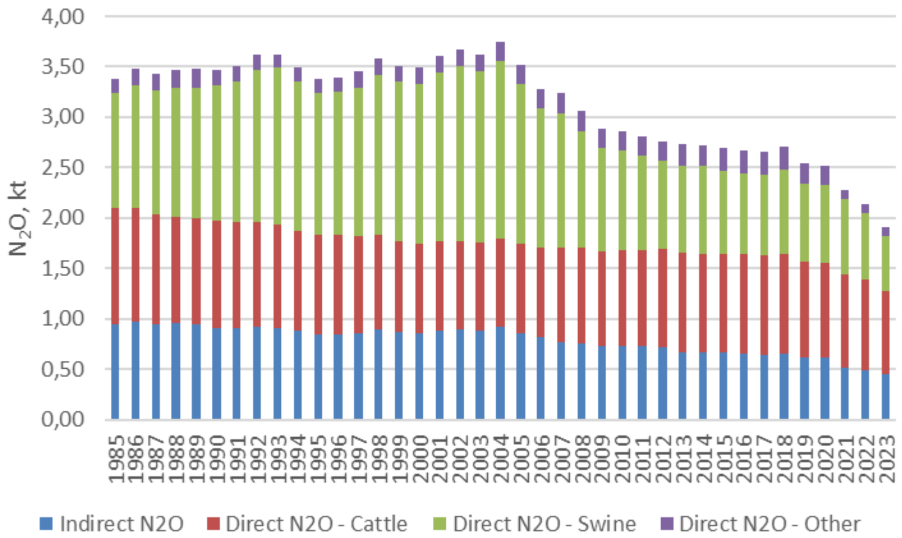

Figure 12.2 N_2O direct and indirect emission from manure management, 1985-2023.

12.1.2 Calculation method

The N_2O emission depends on N excretion in manure, and the barn/manure type. The nitrogen content in animal manure is based on the normative standards (Børsting et al., 2021, Børsting & Hellwing, 2024). Under the anaerobic conditions in slurry and urine, the emission of N_2O is considered to be relatively low, while the emission from deep litter systems and solid manure in the barn units is higher. The direct emission from animal manure management is calculated as shown in equation 12.1.

$$N_2O_{MM,\, direct} = \sum Nex_{j,i} \cdot EF_{j,i} \cdot \frac{44}{28} \qquad \text{(Eq. 12.1)}$$

Where:

$N_2O_{MM,\, direct}$ = direct emission of N_2O from manure management, kg
$Nex_{j,i}$ = N excretion from the given animal category (*j*) and manure type (*i*), kg N
$EF_{j,i}$ = emission factor for a given manure animal category (*j*) and manure type (*i*), based on IPCC (2019), kg N_2O-N per kg N
44/28 = conversion from N_2O-N to N_2O

The indirect emission of N_2O from manure management is calculated as shown in equation 12.2.

$$N_2O_{MM,\, indirect} = \sum N_{Vol} \cdot EF \cdot \frac{44}{28} \qquad \text{(Eq. 12.2)}$$

Where:

$N_2O_{MM,\, indirect}$ = indirect emission of N_2O from manure management, kg N_2O
N_{Vol} = N volatilised as NH_3-N and NO_x-N from manure management, kg N
EF = emission factor based on IPCC (2019), kg N_2O-N per kg N
44/28 = conversion from N_2O-N to N_2O

12.1.3 Activity data

Besides the number of animals (Chapter 4.1), the activity data for direct emission also includes allocation to barn types (Chapter 4.2) and the N excretion for each animal type (Chapter 5.1.3).

Activity data for the indirect emission covers the volatilisation of NH_3 and NO_x, which takes place in barns and during storage of the manure (Chapter 5.1 and 10.1).

12.1.4 Emission factor

For direct emission, a weighted emission factor for cattle and swine slurry with and without natural crust cover is estimated based on the IPCC default N_2O emission factors. For all other manure systems and livestock categories, the IPCC default N_2O emission factors are used. The following table shows the Danish barn system compared to the barn system given in the IPCC 2019 Guidelines Table 10.21 and the respective default emission factors. For cattle slurry, 2 % of the slurry is without crust cover and for swine slurry 5 % are without crust cover.

Table 12.1 Manure management system (MMS) - emission factors.

DK MMS	IPCC MMS	Emission factor, kg N_2O-N per kg N ex
Cattle		
Liquid/slurry	Liquid/slurry, with natural crust cover	0.0049
Solid	Solid storage	0.005
Deep bedding	Cattle and swine deep bedding, no mixing	0.01
Biogas treated slurry	Anaerobic digester	0.0006
Swine		
Liquid/slurry	Liquid/slurry, with natural crust cover	0.00475
Solid	Solid storage	0.005
Deep bedding	Cattle and swine deep bedding, Active mixing	0.07
Biogas treated slurry	Anaerobic digester	0.0006
Poultry		
Barn with or without litter	Poultry manure with or without litter	0.001
Fur bearing animals		
Slurry	Liquid/slurry, with natural crust cover	0.005
Solid	Cattle and swine deep bedding, no mixing	0.01
Sheep and goats		
Deep bedding	Cattle and swine deep bedding, no mixing	0.01
Horses and ostrich		
Deep bedding	Cattle and swine deep bedding, no mixing	0.01

The N_2O emission factor for indirect emission is based on the IPCC (2019) default at 0.014 kg N_2O-N per kg NH_3-N and NO_x-N volatilised.

12.2 Agriculture soils – direct emissions

Direct emissions of N_2O from agricultural soils come from a range of sources. The emission from all sources, apart from cultivation of organic soils and mineralisation, is calculated based on the amount of N applied to soils as shown in equation 12.3.

$$N_2O = N_i \cdot EF_i \cdot \frac{44}{28} \quad \text{(Eq. 12.3)}$$

Where:

N_2O	= emission of N_2O, kg N_2O
N_i	= N applied to soil from the source *i* (inorganic or organic N fertiliser, crop residue, urine and dung deposit during grazing), kg N
EF_i	= emission factor for the source *i* (see Table 12.2), kg N_2O-N per kg N
44/28	= conversion from N_2O-N to N_2O

The emission factors for N_2O from agricultural soils for all sources are based on the default values given by the IPCC (IPCC, 2019). A NH_3 and N_2O emission factor overview is presented in Table 12.2.

Table 12.2 Emission factors – NH_3 and N_2O from agricultural soils – direct emissions.

	NH_3 emission factor (national data)	N_2O emission factor (IPCC default value)
	kg NH_3-N per kg N	kg N_2O -N per kg N
Inorganic N fertilisers	0.05*	0.01[1]
Animal manure applied to soils	0.17**	0.01[1]
Sewage sludge applied to soils	0.11[3]	0.01[1]
Other organic fertilisers applied to soils	0.07[3]	0.01[1]
Urine and dung deposited by grazing animals	0.05-0.35[3]	0.003-0.004[1]
Crop residues		0.01[1]
Mineralization/immobilization associated with loss/gain of soil organic matter		0.01[1]
Cultivation of organic soils		1.6-13***[2]

*Varies from year to year.

**Varies from year to year, has decreased from 0.33 in 1990.

***Unit: kg N_2O-N per ha.

[1] IPCC (2019) Aggregated default.

[2] IPCC (2014).

[3] EMEP (2023).

12.2.1 Inorganic N fertiliser

The amount of nitrogen (N) applied to soil by use of inorganic N fertiliser is estimated from sales statistics and the Danish fertiliser N accounts, see description in Chapter 5.2.

As a result of increasing requirements for improved use of nitrogen in livestock manure and reduce the nitrogen loss to the environment, the consumption of nitrogen in inorganic N fertiliser has decreased from 1985 to 2023 (Table 12.3).

Table 12.3 Nitrogen applied as fertiliser to agricultural soils 1985 – 2023.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
N content in inorganic N fertiliser, kt N	398	400	316	251	206	201	213	252	229	239	197
N_2O emission, kt N_2O	6.26	6.29	4.96	3.95	3.24	3.16	3.35	3.96	3.59	3.75	3.10

12.2.2 Organic N fertiliser

Animal manure applied to soils

The amount of nitrogen applied to soil is estimated as the N excretion in barns which includes N from bedding (Børsting & Hellwing, 2024). The total N excretion in barns from 1985 to 2023 has decreased by 27 %, due to improvement of feed efficiency and change in barn systems.

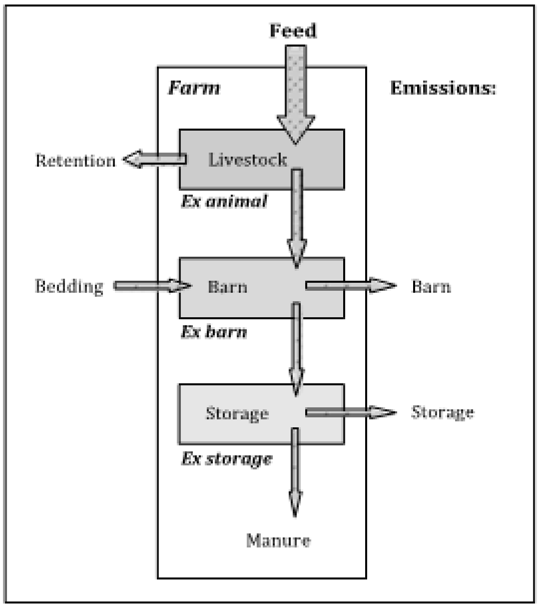

Figure 12.3 The flow dynamics of the Danish Manure Normative Standards, which quantifies nutrient content in livestock manure ex animal, ex barn and ex storage (Luostarinen and Kaasinen, 2016).

Table 12.4 Nitrogen applied as manure to agricultural soils 1985 – 2023.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
N excretion, barn, kt N	270	255	239	235	251	240	238	239	223	213	196
N in manure applied on soil, kt N	221	209	197	195	212	209	212	215	203	193	179
N_2O emission, kt N_2O	3.48	3.28	3.10	3.07	3.33	3.29	3.32	3.37	3.19	3.03	2.81

Sewage sludge

Information about sewage sludge applied on agricultural soil and the content of nitrogen is obtained from a series of reports published by the Danish Environmental Protection Agency, see further description in Chapter 5.4.

Table 12.5 Emission from sewage sludge applied on agricultural soils 1985 – 2023.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Nitrogen in sewage sludge, t N	2 000	3 115	4 635	3 625	2 710	3 622	4 038	5 940	5 040	4 440	5 140
N_2O emission, kt N_2O	0.03	0.05	0.07	0.06	0.04	0.06	0.06	0.09	0.08	0.07	0.08

Other

The category, "Other", includes emission from sludge from industries, which is applied to agricultural soils as fertiliser and biomass other than manure treated in biogas plants.

Information about industrial waste applied on agricultural soils and the content of nitrogen is obtained from a series of reports published by the Danish Environmental Protection Agency, where recent official figures covering year 2001 (Petersen & Kielland, 2003). From 2005 and forward the amount of N from sludge from industries applied to soil, is based on the information registered in the Danish N fertiliser accounts controlled by Agency for Green Transition and Aquatic Environment. The N applied for years 2002- 2004 are interpolated.

Amount of nitrogen applied to soil from biomass treated in biogas plants (other than manure) is based on energy production in biogas plants given in PJ and N per PJ were amount of N from NH_3 emission at the biogas plant are subtracted. See description in Chapter 5.5.

Table 12.6 Emission from sludge from industries and biomass treated in biogas plants applied on agricultural soils 1985 – 2023.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Nitrogen in industrial waste, t N	1 500	1 529	4 445	5 147	2 359	3 401	4 455	5 283	5 425	5 800	5 148
Nitrogen in other biomass, t N	2.7	6.6	12.3	21.0	30.1	36.8	55.8	192.2	238.1	263.5	289.2
N applied on soil	1 503	1 536	4 457	5 168	2 389	3 438	4 511	5 475	5 663	6 064	5 437
N_2O emission, kt N_2O	0.02	0.02	0.07	0.08	0.04	0.05	0.07	0.09	0.09	0.10	0.09

12.2.3 Grazing animals

The amount of nitrogen deposited on grass is based on estimations from the NH_3 inventory (Nielsen et al., 2025b). Information on grazing days is based on expert judgement from DCA and SEGES (Poulsen et al., 2001, Clausen, 2008, Børsting et al., 2021, Martinussen, 2022). N excretion on grass has decreased due to a reduction in the number of dairy cattle and days on grass. Emission factors from IPCC 2019 are used.

The N_2O emission is estimated to 0.24 kt in 1985, decreasing to 0.10 kt in 2023, due to a fall in grazing days for the large dairy cattle farms.

Table 12.7 Nitrogen excreted on grass 1985 – 2023.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
N excretion, grass, kt N	40	37	35	34	26	21	18	17	17	17	16
N_2O emission, kt	0.24	0.23	0.21	0.20	0.15	0.12	0.11	0.10	0.10	0.10	0.10

12.2.4 Crop residues

The emission from crop residues is estimated based on the Tier 1 methodology in the 2019 IPCC Guidelines. However, country specific estimates are used for crop yield and dry matter content. Default values for all parameters given in IPCC 2019 Table 11.2 are used. The default aggregated N_2O emission factor at 0.01 kg N_2O-N per kg N in crop residues is used.

$$N_2O = N_{crop\ reside} \cdot EF \cdot 44/28 \qquad \text{(Eq. 12.4)}$$

Where:

N_2O = emission of N_2O from crop residue, kg N_2O-N
$N_{crop\ residue}$ = nitrogen from crop residue, kg N
EF = emission factor (Table 12.2), kg N_2O-N per kg N
44/28 = conversion from N_2O-N to N_2O

$$N_{crop\ residue} = N_{Above\ ground} + N_{Below\ ground} \qquad \text{(Eq. 12.5)}$$

Where:

$N_{crop\ residue}$ = nitrogen from crop residue, kg
$N_{Above\ ground}$ = total N in above ground residue (Eq. 12.6), kg
$N_{Below\ ground}$ = total N in below ground residue (Eq. 12.7), kg

$$\mathrm{N}_{Above\ ground} = area_i \cdot \left(\left((harvest_i \cdot DRY_i / area_i) \cdot slope_i + intercept_i \right) \cdot \mathrm{N}_{AG,i} \right) \qquad \text{(Eq. 12.6)}$$

Where:

$N_{Above\ ground}$ = total N in above ground residue, kg
i = crop type
Area = area of cultivated crops, ha
Harvest = amount of harvested crops, kg
DRY = dry matter fraction of harvest product, kg DM per kg harvest
Slope = constant given by IPCC (2019) (fractionless)
Intercept = constant given by IPCC (2019) (fractionless)
N_{AG} = N content of above ground residue, kg N per kg DM

$$\mathrm{N}_{below\ ground} = area_i \cdot \left(\left(harvest_i \cdot DRY_i / Frac_{renev,i} / area_i \right) \cdot \mathrm{R}_{BG-BIO} \cdot \mathrm{N}_{BG} \right) \qquad \text{(Eq. 12.7)}$$

Where:

$N_{Below\ ground}$ = total N in below ground residue, kg
i = crop type
Area = area of cultivated crops, ha
Harvest = harvested crops, kg
DRY = dry matter fraction of harvest product, kg DM per kg harvest
$Frac_{renev}$ = fraction of total area of crop type *i* that is renewed annually
R_{BG-BIO} = ratio of below-ground residues to above-ground biomass, kg DM per kg DM
N_{BG} = N content of below-ground residue, kg N per kg DM

The dry matter fraction in crops is based on feedstuff table produced by SEGES (SEGES, 2005), which has information on content of dry matter, fatty acid, protein, starch, sugar and energy for each crop type. The total amount of dry matter in harvest products is based on data from Statistics Denmark and varies from year to year depending on the climatic conditions. See Above-ground residue dry matter in Appendix AA.

The total amount of nitrogen in crop residues is calculated and then the N content in harvested straw is deducted. The N content in crop residues has increased from 121 million kg N in 1985 to 152 million kg N in 2023, which is mainly a result of a lower amount of harvest straw.

Table 12.8 N content in crop residue, million kg N, 1985-2023.

	1986	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Total N in crop residue	151.1	180.3	169.6	175.2	179.9	189.1	206.3	208.0	194.5	206.3	164.8
N in harvested straw	30.0	24.2	20.1	17.4	14.6	14.8	13.6	14.8	13.8	16.0	12.7
N in crop residue	121.1	156.1	149.5	157.8	165.3	174.2	192.7	193.2	180.6	190.3	152.2

The N_2O emission is proportional to the N-amount in crop residues. Figure 12.4 shows the total N-content in crop residues allocated on the main crop types. Increase in N-content for maize and grass-clover mixtures in rotation is a result of increase of cultivated area. Some variations are seen from one year to another due to the annual climate conditions, e.g. in 1992 and 2018 both spring and summer were extremely dry.

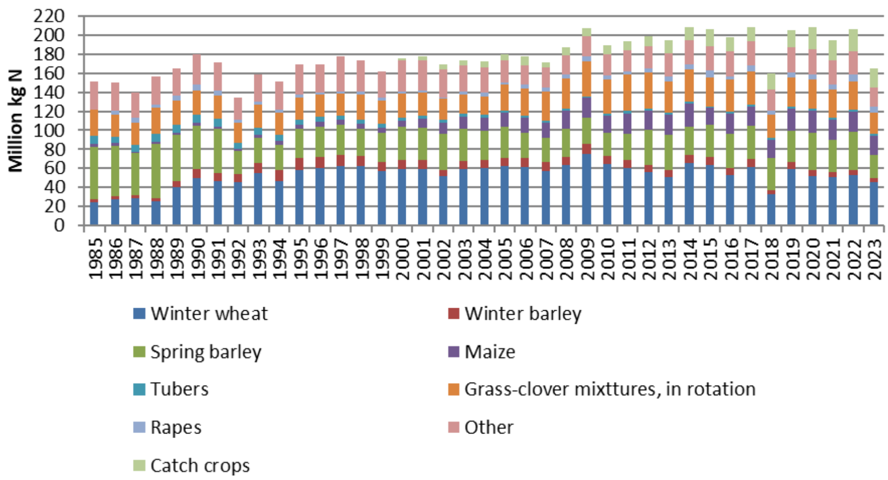

Figure 12.4 Total N in crop residue, 1985 – 2023.

12.2.5 Mineralisation/immobilisation associated with loss/gain of soil organic matter

The N mineralisation from mineral soils associated with loss/gain of soil organic matter is estimated with a dynamic modelling tool - C-TOOL, which is used to estimate long-term changes in carbon from mineral soils. C-TOOL is a 3-pooled dynamic model, where the approximate average half-live times for the three different pools, Fresh organic matter (FOM), Humified organic matter (HUM) and Resilient Organic Matter (ROM) are 0.6-0.7 years, 50 years and 600-800 years, respectively. The main part of biomass returned to soil each year is in the first and easiest degradable FOM pool. This pool consists of mainly fresh straw, fresh manure, root residues, fungi and small animals and fluctuates very much between years depending on the harvest yield and climatic conditions. The annual input to the FOM pool is close to the estimated annual amount of crop residues.

The estimated release of N_2O follows equation 11.8, page 11.20 in IPCC 2019 Guidelines. The N_2O formation is estimated from the annual changes in the HUM and ROM pool. Changes in the FOM pool are considered as being the same as crop residues incorporated in the soil and to avoid double-counting changes in the FOM is not included.

C-TOOL is subdivided into 44 combinations of regions and soil types. Within each subdivision, only losses are included in the estimate. If a subdivision one year has an increase in the HUM and ROM pool the release of N_2O by default are zero as only losses are included, cf. eq. 11.8. A C:N-ratio of 10, which is common in the fertilised Danish agricultural soils are used for all soil types. The recommended default value in the IPCC 2019 Guidelines is 15.

12.2.6 Cultivation of organic soils

Drainage and cultivation of organic soils (humus-rich soils) break down the accumulated organic matter and, thereby, releases both CO_2 and N_2O. The size of the emission depends on the circumstances surrounding cultivation (crop type, rotation, soil management, saturation, pH, etc.). CO_2 emissions are reported in the LULUCF sector of the national inventories. The N_2O emissions are reported in the agriculture sector, except for N_2O emissions from restored wetlands on organic soils, which are also reported in LULUCF. Activity data on the area of organic soils is briefly introduced below and described in further detail in the LULUCF chapter 6, section 6.4.7 of the annual inventory, latest report available in Nielsen et al. (2025). Appendix 3E in Nielsen et al. (2025) by Gyldenkærne and Callisen explains the modelling of the CO_2 emissions in detail.

A revision of the calculation method of the N_2O emissions is expected and planned to be implemented with the 2026 submission. The following description covers the calculations as performed for the submissions up until 2025.

Activity data; mapping of organic soils

Department of Agroecology, Aarhus University, is responsible for the estimates, models and maps used as background data defining the extend and location of organic soils in Denmark. The definition of organic soils within IPCC guidelines is limited to soils with more than 12 % organic carbon (OC) content (IPCC, 2006). The Danish inventory includes only managed organic soils as reported by the farmers in Danish Land Parcel Information System (LPIS) with an OC content of more than 6 %, as defined in the national mappings and in Beucher et al. (2024). The soils with 6-12 % OC also show significant losses of C (Tiemeyer et al., 2016) and make up approximately 50 % of the reported area in Denmark.

The available data has formed three national mappings of organic soils in Denmark, dated to 1975, 2010 and the most recent in 2022. To create a full timeline for the inventory, the area is linearly interpolated for the years 1976-2009 and 2012-2021. In absence of precise data, the distribution of the soils in land use classes is also assumed to be linear.

The 1975 map is based on an estimated total land area with organic soils from the original Danish soil classification provided by DCA. All soils of >6 % OC, were then classified as humus soils and given the soil classification type 'JB11' (Madsen et al., 1992, Greve, 2022). For inventory purposes the soils with above 12 % OC were distinguished through geostatistical analysis on data from the original soil samples (Greve et al., 2014) and the remainder grouped as containing 6-12 % OC. The 2010 map is a statistical map covering all of Denmark based on >10 000 soil samples and mapped information on hydrological conditions that classifies the soils in groups of <3 % OC, 3-6 % OC, 6-12 % OC and >12 % OC. The 2010 map is often referred to as 'Tekstur2014' and described in detail in Adhikari et al. (2013), Greve et al. (2011, 2021). The 2022 map is a form of reconstruction of the 2010 map and is called 'Kulstof2022'/'Peat2022'. Kulstof2022 is two different maps: a distribution map with the average OC % in the upper 30 cm and a peat depth map. It is based on both new samples and re-sampling on sites from the 2010 map, that were used to construct a model projecting the topsoil OC concentration in all the old sampling sites (>10 000). Kulstof2022 showed a large decrease in the number of hectares with ≥6 % OC content and is documented and described in detail in (Beucher et al., 2024). The decrease indicates a loss of carbon and resulted in reclassification of many hectares from organic soils to mineral soils.

Extrapolation since 2022 is carried out by applying the same estimated projection of carbon loss (0.16 % per year) as developed and used for the Kulstof2022 map (Beucher et al., 2024, Weber, 2023) for soils having a peat depth of <34 cm. The extrapolation is performed for each 10*10 m pixels in the Kulstof2022 map and the peat depth map. Prior to submission 2025, which was the first inventory applying the Kulstof2022 map, the extent of organic soils based on Tekstur2014 from 2010 was set as a constant.

As emissions are only reported from managed soils the area impacted by drainage and cultivation of organic soils is based on overlap analysis between Kulstof2022 and information on cultivation and crop types from the Danish (field and) Land Parcel Information System (LPIS). The field information from LPIS is used to categorize the land use into three categories from which N_2O emissions are reported; annual cropping, perennial grasses and areas with previous but no current field identification, which are defined as abandoned lands partly water covered. Each year a number of organic soils are also categorized as Wetlands, based on national information on wetland restoration projects, for which emissions are reported in LULUCF. The extended LPIS data analysis process is carried out mainly as input for the LULUCF sector and described further in the inventory chapter, section 6.4 and 6.5 in Nielsen et al. (2025).

Emission factors

Agricultural soils in use under Danish conditions will normally have a carbon content of around 2 % organic carbon OC (Taghizadeh-Toosi et al., 2014). This is the equilibrium state and drained land under agricultural use will therefore evidently approach an OC content of 1.5-3 %. It is therefore assumed that soils with 6-12 % OC will have losses of CO_2, N_2O and CH_4, but all areas are subdivided into areas with >12 % of OC and 6-12 % OC.

N_2O emissions are calculated using a Tier 1 method based on the 2013 Wetland Supplement, IPCC (2014). The areas with >12 % of OC are multiplied by the default emission factor from Table 2.5 in IPCC (2014) of which for >12 % OC is 13 kg N_2O-N per ha cropland, 8.2 kg N_2O-N per ha deep-drained, nutrient-rich grassland and 1.6 kg N_2O-N per ha shallow-drained, nutrient-rich grassland (abandoned lands only). In submission 2025 all abandoned lands were excluded from the reporting to align with the new data in Kulstof2022. Almost all measurements in the literature are performed on soils having >12 % OC and due to limited measurements in areas with 6-12 % OC, it is chosen to use 50 % of default values for soils having >12 % OC, i.e. 6.5, 4.1 and 0.8 kg N_2O-N per ha, respectively.

$$N_2O_{ORG} = AR_i \cdot EF_i \cdot \frac{44}{28} \qquad \text{(Eq. 12.8)}$$

Where:

N_2O_{ORG}	= emission of N_2O, kg N_2O
AR_i	= area of organic soil, *i* land use type, ha
EF_i	= emission factor, *i* land use type, kg N_2O-N per ha
44/28	= conversion from N_2O-N to N_2O

The emission from cultivation of organic soils has decreased from 2.82 kt N_2O in 1985 to 1.20 kt N_2O in 2023, a decrease of 57 %, which is due to the decrease in the cultivated area with organic soils. The area decreases mainly due to reclassification of the soils from organic soils to mineral soils. When the maps defining the geographical extent and distribution of the organic soils are updated based on more recent data and/or models, many hectares are excluded from the maps, indicating that the organic carbon content of the soil has been mineralized (Beucher et al., 2024).

Table 12.9 Area and N_2O emission for organic soils, 1985-2023.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Cropland, >12 % SOC	55 448	52 502	49 556	46 610	43 664	40 718	26 159	14 555	12 589	10 741	10 592
Grassland, >12 % SOC	51 365	48 636	45 907	43 178	40 449	37 720	37 902	36 112	35 518	34 844	34 610
Cropland, 6-12 % SOC	77 582	75 897	74 213	72 528	70 844	69 159	49 908	33 789	30 940	28 217	26 840
Grassland, 6-12 % SOC	36 838	36 038	35 239	34 439	33 639	32 839	39 952	42 952	43 058	43 000	41 649
N_2O, kt	2.82	2.71	2.59	2.47	2.35	2.24	1.79	1.38	1.31	1.23	1.20

12.3 Agricultural soils – indirect emissions

The emissions from agricultural soils – indirect emissions, are emissions from atmospheric deposition and from leaching and run-off. Agricultural soils – indirect emissions contribute, in 2023 with 18 % of the N_2O emission from the agricultural sector.

12.3.1 Atmospheric deposition

Volatilisation of NH_3 and NO_x and the deposition of these gases and products onto soils and the surface of lakes and other water bodies cause N_2O emission. Emission of N_2O is calculated based on all NH_3 emission sources; manure applied to soil, inorganic N fertiliser, sewage sludge and other organic matter used as fertiliser, urine and dung deposited during grazing, crops, crop residue, ammonia treated straw and field burning of agricultural residue and on NO_x emission sources; manure applied to soil, inorganic N fertiliser, sewage sludge, other organic matter used as fertiliser and urine and dung deposited during grazing.

The emission is calculated as illustrated in Equation 12.9 - i.e. as the total NH_3 and NO_x emission multiplied by the IPCC (2019) standard value for the emission factor of 0.014 kg N_2O-N per kg NH_3-N and NO_x-N volatilised.

$$N_2O_{dep} = \left(\left(NH_3\text{-}N_i + NO_x\text{-}N_j\right) \cdot EF\right) \cdot \frac{44}{28} \qquad \text{(Eq. 12.9)}$$

Where:

N_2O_{dep} = N_2O emission from atmospheric deposition, kg N_2O
NH_3-N_i = NH_3-N volatilised from manure applied to soil, inorganic N fertiliser, sewage sludge and other organic matter used as fertiliser, urine and dung deposited during grazing, crops, crop residue, ammonia treated straw and field burning of agricultural residue, kg N
NO_x-N_j = NO_3-N volatilised from manure applied to soil, inorganic N fertiliser, sewage sludge, other organic matter used as fertiliser and urine and dung deposited during grazing, kg N
EF = emission factor, 0.014 kg N_2O-N per kg NH_3-N and NO_x-N volatilised
44/28 = conversion from N_2O-N to N_2O

The total NH_3 and NO_x emission from all emission sources is shown in Table 12.10 together with the calculated N_2O emission. From 1985 to 2023, the N_2O emission has decreased from 2.17 kt N_2O to 0.80 kt N_2O, which equates to a fall of 63 %. As mentioned in Chapter 5 regarding the NH_3 emission, this emission reduction is a consequence of environmental policies to reduce the loss of nitrogen to the aquatic recipients.

Table 12.10 Total NH_3, NO_x emission and the N_2O emission, 1985 – 2023.

Emission per year	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
NH_3 emission, kt NH_3-N	90.7	84.8	64.7	50.0	37.5	37.0	35.8	37.6	35.8	35.0	31.6
NO_x emission, kt NO_x-N	8.1	7.9	6.8	6.0	5.5	5.3	5.5	6.0	5.6	5.6	4.9
N_2O emission, kt N_2O	2.17	2.04	1.57	1.23	0.95	0.93	0.91	0.96	0.91	0.89	0.80

12.3.2 Leaching and runoff

Nitrogen, which is transported through the soil, can be transformed to N_2O. The IPCC (2019) recommends an N_2O emission factor of 0.011, of which 0.006 is for leaching to groundwater, 0.0026 for transport to watercourses (in IPCC definition called rivers) and 0.0026 for transport out to sea (in IPCC definition called estuaries). The N_2O emission from nitrogen leaching is a sum of the emission for all three parts calculated as given in Equation 12.10:

$$N_2O_{leaching} = \left(N_{leach\text{-}ground} \cdot EF_{ground} + N_{leach\text{-}rivers} \cdot EF_{rivers} + N_{leach\text{-}estuatires} \cdot EF_{estuatires}\right) \cdot \frac{44}{28} \quad \text{(Eq. 12.10)}$$

Where:

$N2O_{leaching}$ = emission, kg N_2O
N = N leached to ground water, rivers and estuaries, kg N
EF = emission factor for ground water, rivers and estuaries kg N_2O-N per kg N
44/28 = conversion from N_2O-N to N_2O

In connection with the Action Plans for the Aquatic Environment, nitrogen leaching to groundwater, rivers and estuaries has been estimated. The calculation of N to the groundwater is based on two different models; SKEP/Daisy and N-LES (Børgesen & Grant, 2003) carried out by DCA and DCE (see overview of model in Appendix AB). SKEP/DAISY is a dynamical crop growth model taking into account the growth factors, whereas N-LES is an empirical leaching model based on more than 1500 leaching studies performed in Denmark during the last 15 years. The models produce rather similar results for nitrogen leaching on a national basis (Waagepetersen et al., 2008). The SKEP/Daisy model has estimated the total N leached from 2003-2011 to be from 149-174 thousand tonnes N, whereas the N-LES model has estimated the total N leached to be from 161-170 thousand tonnes in the same period. An average of the results from the two models is used in the emission inventories. From 2012 to 2023, data from N-LES is used.

Data concerning the N leaching to rivers and estuaries are based on data from NOVANA (National Monitoring program of the Water Environment and Nature) received from the Department of Ecoscience, Aarhus University (Windolf et al., 2011, Windolf, 2013, Tornbjerg, 2024). NOVANA is a monitoring program, which includes monitoring of the ecological, physical and chemical condition of water areas and transport of water and a range of substances, including N, to lakes and the sea (Wiberg-Larsen et al., 2010). These studies include measurements from 223 monitoring stations in all parts of Denmark, and they have been carried out since the early 1990s.

Since 1985, the amount of nitrogen leached has almost halved as a result of the significant decrease in consumption of inorganic N fertilisers and the improved utilisation of the nitrogen content in animal manure (Table 12.11). The same trend is reflected in the N_2O emission by a decrease from 3.8 kt N_2O in 1985 to 1.9 kt N_2O in 2023.

Table 12.11 Leaching of nitrogen and associated emissions, 1985 - 2023.

	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023*
N $leaching_{groundwater}$, kt N	304	267	235	179	162	167	153	149	141	129	136
N $leaching_{rivers}$, kt N	120	96	94	89	58	58	86	77	58	56	81
N $leaching_{estuaries}$, kt N	118	99	86	77	53	55	70	57	50	45	65
N_2O, kt	3.84	3.31	2.95	2.37	1.98	2.04	2.08	1.95	1.76	1.63	1.88

*Data for groundwater received from Thorsen (2024) and for rivers and estuaries Tornbjerg (2024).

Figure 12.5 illustrates on the first axis the total amount of nitrogen applied as fertiliser on agricultural land in the form of animal manure, inorganic N fertiliser, sewage sludge, other organic fertiliser, crop residues and mineralisation, while the second axis shows the amount of N leached to the groundwater. The percentage of N leached compared with the total N applied on soil has decreased from 37 % in 1985 to 24 % in 2023.

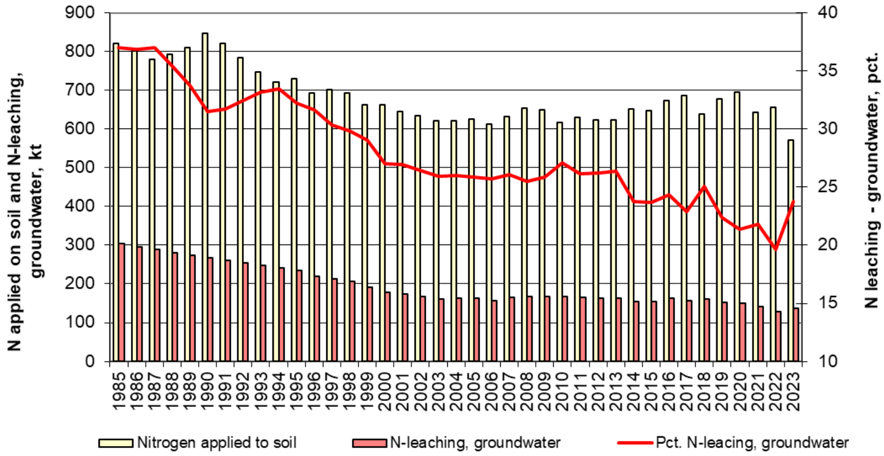

Figure 12.5 Leaching of nitrogen from 1985 to 2023.

13 Carbon dioxide

Emission of carbon dioxide (CO_2) from the agricultural sector comes from three sources: field burning of agricultural residue, liming and inorganic N fertiliser. For calculation etc. of emission from field burning, please refer to Chapter 7. Emission of CO_2 from field burning is not reported in the Danish emission inventories, because no cells in Common Reporting Tables (CRT) allows to register this emission pollutant.

13.1 Liming

The emission of CO_2 from liming in Denmark occurs during liming with limestone.

13.1.1 Emission

The emission of CO_2 from liming has overall decreased by 74 % from 1985 to 2023. As shown in Figure 13.1, the main decrease is occurring from 1985 to 1997 and is due to a change in fertiliser practice with increase in use of manure as fertiliser and decrease in use of inorganic N fertiliser. When ammonium nitrogen (inorganic N) is used as fertiliser and a loss of nitrogen from the soil is occurring, it causes an acidification of the soil and use of liming could be necessary to even out pH in the soil (Knudsen, 2004).

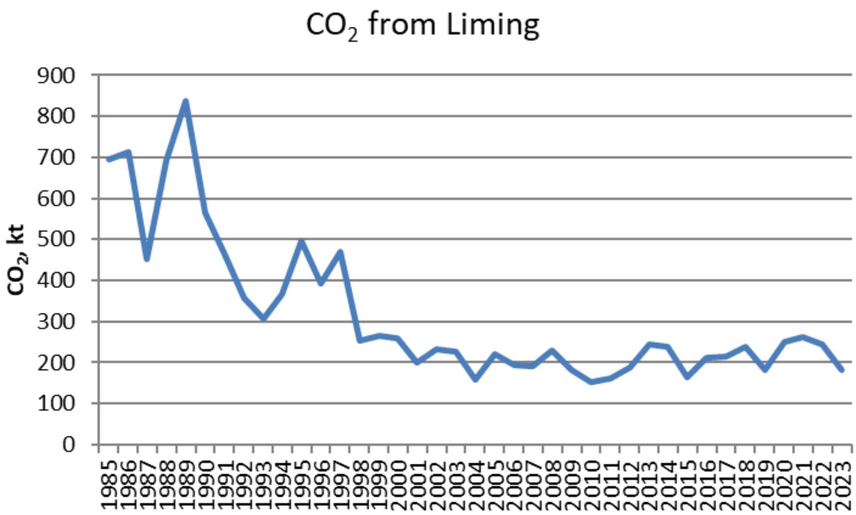

Figure 13.1 CO_2 emission from liming, 1985 to 2023.

13.1.2 Calculation method

A Tier 1 method as given in IPCC 2019/2006 is used.

$$CO_2 = A_{lime} \cdot EF \quad \text{(Eq. 13.1)}$$

Where:

CO_2	= emission of CO_2, kt
A_{lime}	= lime, kt $CaCO_3$
EF	= emission factor (see Chapter 13.1.3), kt CO_2 per kt limestone

13.1.3 Activity data

The amount of limestone used is based on the sales statistics. The amount used on the agricultural soils is collected by SEGES (Hansen, 2024). The amount of limestone used in private gardens is based on expert judgement (Andersen, 2004, Pers. Comm.) and the same value is used for all years.

13.1.4 Emission factors

The emission factor is 4.4 kt CO_2 per kt limestone and the same for all years 1985 to 2023. It is based on the molecular weight for $CaCO_3$, CO_2 and C.

$$\text{EF}=\text{M}_{CaCO_3} \cdot \text{M}_C \cdot \frac{M_{CO_2}}{\text{M}_C}$$

Where:

EF	= emission factor for CO_2 from liming, kt CO_2 per kt limestone
M_i	= molecular weight for *i* molecule

13.2 Fertiliser

13.2.1 CO_2 from urea

Emission of CO_2 from use of urea contributes with 7 % of the CO_2 emission from the agricultural sector in 2023, but for the years 2003-2021 the emission of CO_2 from use of urea contributed with less than 1 %.

A Tier 1 method as given in IPCC 2019/2006 is used.

$$\text{CO}_2 = A_{urea} \cdot \text{EF} \cdot \frac{44}{12} \qquad \text{(Eq. 13.2)}$$

Where:

CO_2	= emission of CO_2, kt
A_{urea}	= urea, kt
EF	= emission factor, 0.20 kt C per kt urea

The amount of urea used on agricultural soils is based on sales estimates from Danish Agency for Agriculture and Fisheries (LFST, 2023) and from the Danish fertiliser N accounts controlled by Agency for Green Transition and Aquatic Environment (SGAV, 2024). The default emission factor of 0.20 t C per t urea given in IPCC 2019/2006 is used.

Figure 13.2 shows the emission of CO_2 from use of urea. The emission increased with 27 % from 1985 to 2023 but changed during the years 1985-2023. In the period 1985-1994, an increase is seen and then from 1994-2003 the emission was decreased by 96 %. From 2003 to 2021, the emission is almost unaltered. In 2022, the use of urea had increased significantly, due to regulation of tax on urea made by EU, which lowered the prize. In 2023, the use of urea has decreased a bit compared to 2022.

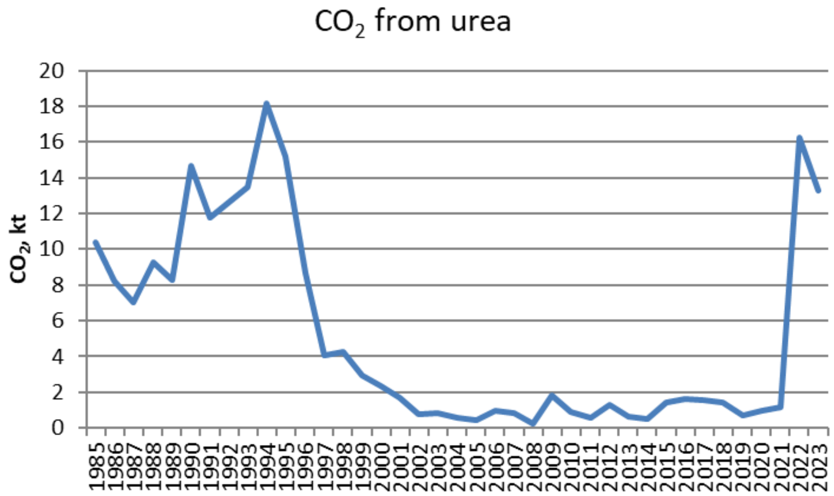

Figure 13.2 Emission of CO_2 from use of urea, 1985 to 2023.

13.2.2 CO_2 from other carbon containing fertilisers

Use of other carbon containing fertilisers is in Denmark the use of calcium ammonium nitrate (CAN). The emission of CO_2 from CAN contributes with 2 % of the CO_2 emission from the agricultural sector in 2023.

A Tier 1 method as given in IPCC 2019/2006 is used.

$$CO_2 = A_{CAN} \cdot EF \cdot \frac{44}{12} \quad \text{(Eq. 13.3)}$$

Where:

CO_2 = emission of CO_2, kg
A_{CAN} = CAN, kg
EF = emission factor, (see Equation 13.4 and 13.5), kg CO_2 per kg CAN

The amount of CAN used on agricultural soils is based on sales estimates from LFST (2023) and from the Danish fertiliser N accounts controlled by SGAV (2024).

The emission factor is 0.026 kg CO_2 per kg CAN and the same for all years 1985 to 2023. It is based on the molecular weight:

$$EF = \left(\frac{\text{kg } CaCO_3}{\text{kg CAN}} / 100\right) \cdot M_{CaCO_3} \cdot M_C \cdot \frac{M_{CO_2}}{M_C} \quad \text{(Eq. 13.4)}$$

$$\frac{\text{kg } CaCO_3}{\text{kg CAN}} = \left(100 - M_{NH_4NO_3}\right) / M_{CaMg(CO_3)_2} \cdot M_{CaCO_3} \cdot 2 \quad \text{(Eq. 13.5)}$$

Where:

EF = Emission factor for CO_2 from CAN, kg CO_2 per kg CAN
M_i = Molecular weight for *i* molecule

Figure 13.3 shows the emission of CO_2 from use of CAN. The emission decreased with 78 % from 1985 to 2023, but the main decrease is occurring from 1989 to 1999. From 2000 to 2023, the emission is almost unaltered except from in 2015 and 2022 where an increase is seen, this is due to increase in the use of CAN.

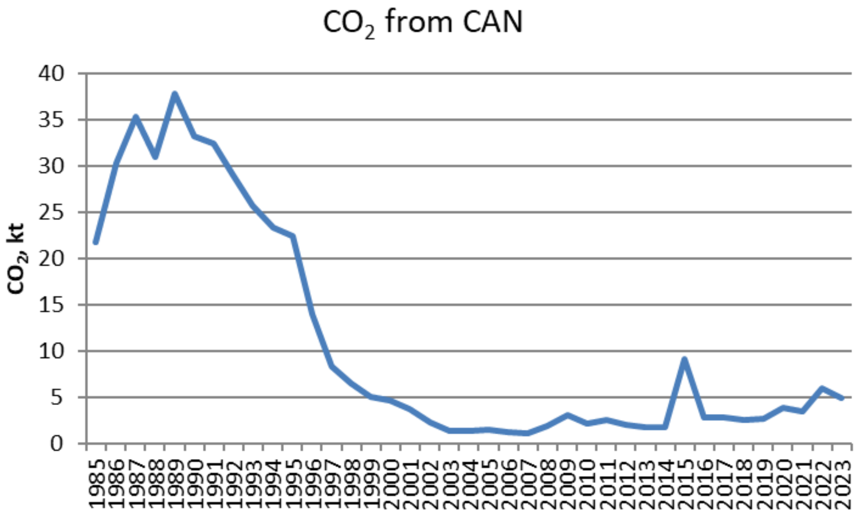

Figure 13.3 Emission of CO_2 from use of CAN, 1985 to 2023.

14 Quality assurance and quality control

A first step of the development and implementation of a general QA/QC plan for the Danish emission inventories was initiated in 2004, which is described in a manual (Sørensen et al., 2005; Nielsen et al., 2013). The manual describes the concepts of quality work and how to handle quality management by using Critical Control Points and a list of Point of Measurements (PM).

This report describes in detail the methods and the data foundation used to estimate the agricultural emissions, and together with the National Inventory Document (NID) and the Informative Inventory Report (IIR), a high degree of transparency is ensured.

The check of comparability with the reporting of other countries is ensured through the international review processes, where a lot of parameters are compared across countries and compared to the IPCC default. Additionally, Denmark has carried out a project of verification, where the emissions from key categories in the Danish inventories were compared against other countries with similar circumstances. (Fauser et al., 2007 and 2013).

One of the key elements to assess the accuracy of the inventories is estimating the uncertainties of the emission estimates. The procedure for estimating the uncertainties is described in Chapter 15.

As quality assurance, the most important aspects are external reviews of the inventories by independent experts. For the Danish agricultural inventories, the external review consists of two main elements.

The first element is the international reviews carried out under the UNFCCC and UNECE. These reviews consist of review teams of internationally appointed experts, who are assigned to review the reporting of the different countries. These review teams consist of experts within all sectors and therefore cover the entire emission inventories. The recommendations received by the review teams form an important basis for improving both the inventories themselves but also the documentation.

The second element is the external review of the sectorial reports, such as this one. The sectorial reports are externally reviewed by national or international experts in the field.

The first version of this report (Mikkelsen et al., 2006) was reviewed by Statistics Sweden, who is responsible for the Swedish agricultural inventory. The first updated report (Mikkelsen et al., 2011) was reviewed by Nicholas J. Hutchings from the Faculty of Agricultural Sciences, Aarhus University and by Johnny M. Andersen from the Faculty of Life Sciences, University of Copenhagen. The second updated rapport (Mikkelsen et al., 2013) was reviewed by Heidi Ravnborg from the Danish Environmental Agency. The third updated rapport (Albrektsen et al., 2017) was reviewed by senior scientist Peter Lund, Department of animal science, Aarhus University, with a specific focus on Chapter 11. The fourth updated rapport (Albrektsen et al., 2021) was reviewed by Anders Peter Adamsen, senior scientist at the Department of Engineering, Aarhus University.

The current report is reviewed by Tommy Dalgaard, professor at Department of Agroecology, Aarhus University.

14.1 QA/QC plan

The overall framework regarding a QA/QC plan is constructed as six stages, and each stage focuses on quality assurance and quality check in different parts of the inventory process. A more detailed set up for stage I, II and III are provided, referring to Appendix AC.

The QA/QC procedure is divided in six stages as listed below:

Table 14.1 Stages of QA/QC procedure.

Stage I	**Check of input data** - check of data input in IDA are consistent with data from external data suppliers
Stage II	**Check of IDA data – overall** - check of recalculations for total emissions compared with the latest submission - check of total emissions for the total CO_2 eqv. and for each compound
Stage III	**Check of IDA data – specific** - check of annual changes of activity data, emission factors, IEF and other important variables as GE, N ex, barn system distribution, grazing days
Stage IV	**Check by comparing calculation with estimates from other institutions** - the total N ex for all livestock production estimated by DCA - the Register for fertilisation controlled by the Danish Agricultural Agency
Stage V	**Check of data registered in the Common Reporting Tables (CRT) reported to UNFCCC and Nomenclature for Reporting (NFR) to UNECE** - compare data in CRT or NFR with data from IDA
Stage VI	**Check of the inventories in general (external review)** - check that data is used correctly - check the methodology and the calculations

Stage I: Check of input data

At stage I, it is checked that all input data in IDA is consistent with data from the external data suppliers. Data from Statistics Denmark must be checked for the livestock production, slaughter data for pigs, bulls and poultry, check of land use and crop yield. Data input from the DCA must be checked for feed intake, N excretion, manure production, dry matter content and grazing days. Check of data for the distribution of barn systems from Agency for Green Transition and Aquatic Environment (SGAV) and the use of nitrogen in inorganic N fertiliser from Danish Agency for Agriculture and Fisheries (LFST).

Stage II: Check of IDA data - overall

Stage II includes checks of the overall calculations in IDA. The first step is to compare the inventory with the last reported emission inventory. In cases where an error covers all time series, it can be difficult to identify this error by checking the changes in inter annual values. Therefore, a check of recalculations is needed.

Next step in stage II is a check of total emissions of NH_3, CH_4, N_2O, NMVOC, NO_x, PM and the other compounds, which are related to the field burning of agricultural residues and use of pesticides. For each compound, a check of trends of times series 1985-2023 and inter annual changes are provided. Significant jumps or dips from one year to another could indicate an error - otherwise it must be explained.

Stage III: Check of IDA data - specific

At stage III, a check of specific variables in IDA is provided for both inter annual changes and trends for the entire time series. Variables include activity data, emission factors, IEFs and other important key variables such as feed intake, gross energy (GE), N ex and barn system distribution.

Stage IV: Check by comparing calculation with estimates from other institutions

The purpose of stage IV is to verify the calculations in IDA, as far as external data estimations are available. For other purposes DCA for some years calculate the overall N excretion from the total livestock production in DK, this is compared with the estimated values in the emission inventory (Nielsen et al., 2025a).

Another possibility to check some of the IDA estimations is the information in the fertiliser accounts controlled by SGAV. Farmers with more than 10 animal units must be registered and must keep accounts of the N content in manure, received manure or other organic fertilisers. These comparisons will properly show some differences, which do not necessarily indicate an error, but the most important cause of the difference must be identified.

Stage V: Check of data registered in CRF and NFR

Stage V primarily focuses on the last reported year and the base year (CRT 1990/NFR 1985), where all activity data, emissions and IEFs are checked. Furthermore, CRT and NFR sum emissions are checked with sum emissions in IDA. If an error is detected a more detailed check is done to find the reason for the error.

Stage VI: Check of the inventories in general

General checks of the inventories include considerations of which data input is used, how they are used in the calculations and whether more accurate data are available. The review of this sectorial report addresses these issues and is the most valuable part of the QA of the agricultural sector.

As mentioned above, international reviews are carried out under the UNFCCC and UNECE. Every submission is reviewed by review teams with internationally appointed experts, who are assigned to review the reporting of the different countries. These review teams consist of experts within all sectors and therefore cover the entire emission inventories. The review process can result in a range of recommendations which can improve the inventories and form an important basis for improving both the inventories themselves but also the documentation.

Some years the review of the GHG inventory is an in-country review, where a review team visits the country and the review consist of a thorough review of the reporting, both numbers and documentation and dialog between the reviewers and sector experts. In 2025 Denmark had an in-country review, which for the agricultural sector resulted in an encouragement for closely collaboration with the Danish institute responsible for submitting the official statistical data on inorganic fertilisers to Eurostat in order to improve the consistency between data, a recommendation for updating the uncertainty for the activity data for inorganic fertilisers and a recommendation to enhance the transparency for the activity data for organic soils (estimation of area).

15 Uncertainties

Uncertainty estimates are based on the methodology described in 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), IPCC 2019 Refinement (IPCC, 2019) and the EMEP/EEA Guidebook (EMEP, 2023). The total uncertainty depends on uncertainty values for activity data and uncertainty values for the emission factor.

15.1 Uncertainty values for agricultural air pollutants

15.1.1 Activity data

As mentioned before, the main part of the emissions depends on the livestock production, and uncertainties such as number of animals, feeding consumption, normative standards etc. are relatively low. The uncertainties for the most important livestock categories are relatively low, e.g. for swine and cattle the uncertainties are estimated to 1.3 % and 0.9 %, respectively. The uncertainty is higher for less important animal groups, e.g. fur bearing animals (3.4 %), poultry, horses and sheep (10.4 %) (DSt, 2024). The uncertainty about the number of animals overall is estimated to 2 %.

The allocation of barn system is based on information from the farm nitrogen budgets handled and controlled by SGAV. All farmers must submit the information regarding the barn type annually and the uncertainty is assumed as relatively low.

When it comes to NH_3 emission, from manure management, the activity data not only includes the number of animals but also includes estimates for type of barn and thus type of manure, which increases the uncertainty. The uncertainty value is estimated to 5 %, see Table 15.1.

The overall uncertainty for N excretion on grass is estimated to 5 %. Besides the number of animals, the uncertainty depends on the assumed number of days on grass and the N excretion, which is estimated by SEGES and DCA, Aarhus University. The Danish Normative Standards for animal excretions is based on data from SEGES, which is the central office for all Danish agricultural advisory services. The database contains data on diet composition, feed utilisation and production parameters like milk yield, daily gain, pigs per litter, egg production, etc. The data represents more than 50 % of all dairy herds, and a higher proportion of all dairy cows. For slaughter calves' data represented about 60 % of the slaughtered animals. The swine values were based on 700 000 sows equivalent to 70 % of all sows, and the data from fattening pigs were based on 8.7 million pig equivalents to about 60 % of all pigs slaughtered in Denmark (Børsting, 2024). For poultry 80-90 % of the production and approximately 100 % of the fur production was covered. With the very large proportion of the cattle, swine and poultry farms yielding data to the database these data are considered to be very representative for Danish animal production. In the normative standards (Børsting & Hellwing, 2024) uncertainty values are indicated for emission measurements in barns and varies from 15 - 25 %.

The activity data for inorganic N fertiliser depends on the amount of fertiliser sold and the nitrogen content, which is based on information given by the SGAV. Uncertainty for this is considered to be low and is estimated to 3 %[3].

For manure applied to soil the activity data is a combination of number of animals, barn type, N excretion, days on grass and emission factors for NH_3 in barns and storage. The combined uncertainty is estimated to 15 %.

An uncertainty of 25 % for the activity for field burning of agricultural residue is used. The uncertainty is a combination of the uncertainty for area of grass for seed production, which has a low uncertainty, amount of burnt straw and yield, which have a high uncertainty.

The uncertainty for activity data regarding use of pesticides with HCB is based on annual sales statistics provided by the Environmental Protection Agency and is considered with relatively low uncertainty; 5 %.

See Table 15.1 for other variables and their uncertainty estimates.

15.1.2 Emission factor

The uncertainty regarding the NH_3 emission factor from manure management is based on Kai et al. (2024a and 2024b) and estimated to 25 %. The uncertainty estimations are based on measurements and model estimations.

The ammonia emission from grazing animals depends on the number of grazing days, the animal type, the temperature and other climatic conditions. No statistics exist on the number of grazing days and are therefore based on an estimate provided by SEGES. The uncertainty value is estimated to 25 %.

No uncertainty values for the emission factor regarding the inorganic N fertiliser are given in the EMEP/EEA guidebook. The Danish inventories assume an uncertainty value of 25 %, which indicated an uncertainty in the translation of the Danish fertiliser types to types specified in the guidebook, but also indicate an uncertainty of the emission factors specified in the guidebook.

The uncertainty regarding the emission from the ammonia emission sources cultivated crops, sewage sludge and ammonia treated straw is all based on the relative few data and therefore assumed to have a high uncertainty estimated to 50 %.

For NMVOC, PM and NO_x the uncertainty for the emission factors is based on EMEP/EEA guidebook.

Uncertainties for field burning are relatively high. The uncertainties for the emission factors for field burning of agricultural residues are based on the EMEP/EEA Guidebook (EMEP, 2023) and Jenkins et al. (1996).

No uncertainty value is provided in EMEP for HCB and PCBs, the uncertainty is assumed to be high and thus estimated to 500 %.

[3] This uncertainty will be updated in submission 2026.

Table 15.1 Variables and uncertainty values, air pollutants.

NFR code	Compound	Source	Activity data uncertainty	Emission factor uncertainty
3.B	NH_3	Manure management (barn+storage)	5 %	25 %
3.Da1	NH_3	Inorganic fertilisers	3 %	25 %
3.Da2a	NH_3	Animal manure applied	15 %	25 %
3.Da2b	NH_3	Sewage sludge applied	15 %	50 %
3.Da2c	NH_3	Other organic fertiliser	15 %	50 %
3.Da3	NH_3	Urine and dung deposited by grazing	5 %	25 %
3.Da4	NH_3	Crop residues applied to soils	25%	135%
3.De	NH_3	Cultivated crops	2 %	50 %
3.F	NH_3	Field burning	25 %	50 %
3.I	NH_3	NH_3 treated straw	20 %	50 %
3.B	PM	Manure management	7 %	300 %
3.Dc	PM	Cultivation of soils	10 %	300 %
3.F	PM	Field burning	25 %	50 %
3.B	NO_x	Manure management	5 %	100 %
3.Da1	NO_x	Inorganic fertilisers	3 %	400 %
3.Da2a	NO_x	Animal manure applied	15 %	400 %
3.Da2b	NO_x	Sewage sludge applied	15 %	400 %
3.Da2c	NO_x	Other organic fertiliser	15 %	400 %
3.Da3	NO_x	Urine and dung deposited by grazing	5%	400%
3.F	NO_x	Field burning	25 %	25 %
3.B	NMVOC	Manure management	2 %	300 %
3.Da2a	NMVOC	Animal manure applied	15%	300%
3.Da3	NMVOC	Urine and dung deposited by grazing	15%	300%
3.De	NMVOC	Cultivated crops	5 %	500 %
3.F	NMVOC	Field burning	25 %	100 %

15.1.3 Result of the uncertainty calculation

Table 15.2 shows uncertainty values for activity and emission factors and combined and total uncertainties for the air pollutants. The uncertainty estimates are based on the simple Tier 1 approach in the EMEP/CorinAir *Good Practice Guidance for LRTAP Emission Inventories* (Pulles & Aardenne, 2004).

The total uncertainty for the NH_3 emission inventories is calculated at ±14 % (see Table 15.2), which is primarily affected by the main emission source manure management. The higher uncertainty values for the field burning of crop residues have only minor effect on the total uncertainty estimate.

A high total uncertainty of around 100 % to 500 % is associated with NO_x emission, NMVOC emission, PM emission and almost all pollutants related to field burning of agricultural residues. The high uncertainty level is due to the emission factors' uncertainty.

Table 15.2 Uncertainty values for air pollutants, 2023.

Pollutant	NFR category	Emission, kt	Activity data, %	Emission factor, %	Combined uncertainty, %	Total uncertainty, %
NH_3, kt	3B Manure management	24.65	5	25	25	14
	3Da1 Inorganic N-fertilizers	11.58	3	25	25	
	3Da2a Animal manure applied	15.74	15	25	29	
	3Da2b Sewage sludge	0.67	15	50	52	
	3Da2c Other organic fertiliser	0.43	15	50	52	
	3Da3 Grazing animals	2.26	5	25	25	
	3Da4 Crop residues	1.33	25	135	137	
	3De Cultivated crops	6.32	2	50	50	
	3F Field burning	0.04	25	50	56	
	3I Agriculture other	0.01	20	50	54	
TSP, kt	3B Manure management	6.65	7	300	300	270
	3Dc Agricultural operations	56.59	10	300	300	
	3F Field burning	0.09	25	50	56	
PM_{10}, kt	3B Manure management	2.29	7	300	300	228
	3Dc Agricultural operations	5.66	10	300	300	
	3F Field burning	0.09	25	50	56	
$PM_{2,5}$, kt	3B Manure management	0.54	7	300	300	197
	3Dc Agricultural operations	0.43	10	300	300	
	3F Field burning	0.08	25	50	56	
NMVOC, kt	3B Manure management	37.50	2	300	300	252
	3Da2a Animal manure applied	5.86	15	300	300	
	3Da3 Grazing animals	0.07	15	300	300	
	3De Cultivated crops	1.90	5	500	500	
	3F Field burning	0.01	25	100	103	
NO_x, kt	3B Manure management	0.72	5	100	100	253
	3Da1 Inorganic N fertilisers	7.89	3	400	400	
	3Da2a Animal manure applied	7.13	15	400	400	
	3Da2b Sewage sludge	0.21	15	400	400	
	3Da2c Other organic fertiliser	0.22	15	400	400	
	3Da3 Grazing animals	0.66	5	400	400	
	3F Field burning	0.04	25	25	35	
HCB, kg	3Df Use of pesticides	0.23	5	500	500	367
	3F Field burning	0.13	25	500	501	

Table 15.2 Continued

Pollutant	NFR category	Emission, kt	Activity data, %	Emission factor, %	Combined uncertainty, %	Total uncertainty, %
PCB, kg	3F Field burning	0.00002	25	500	501	501
SO_2, kt	3F Field burning	0.01	25	100	103	103
BC, kt	3F Field burning	0.01	25	100	103	103
CO, kt	3F Field burning	1.03	25	100	103	103
Pb, t	3F Field burning	0.00	25	50	56	56
Cd, t	3F Field burning	0.01	25	100	103	103
Hg, t	3F Field burning	0.002	25	200	202	202
As, t	3F Field burning	0.0001	25	100	103	103
Cr, t	3F Field burning	0.00	25	200	202	202
Cu, t	3F Field burning	0.001	25	200	202	202
Ni, t	3F Field burning	0.001	25	200	202	202
Se, t	3F Field burning	0.0003	25	100	103	103
Zn, t	3F Field burning	0.009	25	200	202	202
Dioxin, g I-Teq	3F Field burning	0.03	25	500	501	501
(a)*, t	3F Field burning	0.01	25	500	501	501
(b)*, t	3F Field burning	0.02	25	500	501	501
(k)*, t	3F Field burning	0.01	25	500	501	501
(1,2,3 cd)*, t	3F Field burning	0.01	25	500	501	501

*(a) - Benzo(a)pyrene, (b) - Benzo(b)fluoranthen, (k) - Benzo(k)fluoranthen, (1,2,3 cd) - Indeno(1,2,3 cd)pyrene

15.2 Uncertainty values for agricultural greenhouse gases

15.2.1 Activity data

The activity data regarding CH_4 emission from enteric fermentation only depends on number of animals and feeding consumption, number of animals is based on very reliable data from Statistics Denmark, thus a low uncertainty at 2 % is used. Activity data for manure management besides number of animals also depends on the barn - and manure type. The uncertainty estimate is assumed to be 5 %.

Uncertainty for N_2O activity data, which depends on the ammonia emission such as manure management, manure applied to soils and the atmospheric deposition, reflects the uncertainty value estimated in the ammonia emission inventories (See the combined uncertainty provided in Table 15.2).

Activity regarding crop residue, mineralization and cultivation of organic soils depends on land use data from Statistics Denmark, which has a low uncertainty. However, activity data also depends on the yield and the crop's N content, which is much more uncertain. An uncertainty value at 25 %, 50 % and 50 %, respectively, is used. The uncertainty level for data on the amount of nitrogen leached to groundwater, watercourses and to the sea are estimated to 20 %.

As for the air pollutants, an uncertainty of 25 % for field burning of agricultural residue is used.

15.2.2 Emission factor

The uncertainty value for enteric fermentation is in IPCC guidance estimated to 20 %. Uncertainty regarding the emission factor used for manure management depends on the uncertainty for each variable such as manure excretion, distribution of barn type, content of dry matter in manure and use of straw for bedding. National data is used for these variables, which may reduce the uncertainty compared with use of IPCC default value. It is considered that an uncertainty of 20 % is reliable.

A CH_4 and N_2O uncertainty for field burning is estimated to 50 %, which is based on IPCC guidelines.

The IPCC default value is used to calculate the uncertainty of the N_2O emission. The uncertainty estimates mentioned in IPCC guidance show an 80 % uncertainty for N applied, a high uncertainty for grazing animals of 250 %, for atmospheric deposition an uncertainty of 21 % and for leaching of 100 %.

Table 15.3 Variables and uncertainty values, GHG.

CRF code	Compound	Source	Activity data uncertainty	Emission factor uncertainty
3.A	CH_4	Enteric fermentation	2%	20%
3.B	CH_4	Manure management	5%	20%
3.B	N_2O	Manure management	20%	100%
3.B5	N_2O	Atmospheric deposition	15%	80%
3.D.1.a	N_2O	Inorganic N fertiliser	3%	80%
3.D.1.b.i	N_2O	Animal manure applied	25%	80%
3.D.1.b.ii	N_2O	Sewage sludge applied	15%	80%
3.D.1.b.iii	N_2O	Other organic fertiliser	20%	80%
3.D.1.c	N_2O	Grazing animals	10%	250%
3.D.1.d	N_2O	Crop residue	25%	80%
3.D.1.e	N_2O	Mineralization	50%	80%
3.D.1.f	N_2O	Histosols	50%	40%
3.D.2.a	N_2O	Atmospheric deposition	15%	21%
3.D.2.b	N_2O	Leaching	20%	100%
3.F	N_2O	Field burning	25%	50%
3.F	CH_4	Field burning	25%	50%
3.G	CO_2	Liming	5%	100%
3.H	CO_2	Urea	3%	100%
3.I	CO_2	CAN	3%	100%

15.2.3 Result of the uncertainty calculation

Table 15.4 shows the result of Approach 1 uncertainty estimation for 2023, based on the Approach 1 methodology in the 2006 IPCC Guidelines (IPCC, 2006). The overall uncertainty calculation for the agricultural sector based on Approach 1 is estimated to ±15 %.

Table 15.4 Uncertainty calculation, 2023.

		Emission, kt CO_2 eqv.	Uncertainty, % Lower and upper (±)
3 Agriculture total		11 223	15
3A Enteric fermentation	CH_4	3 974	20
3B Manure management		3 670	21
	CH_4	3 164	21
	N_2O	386	102
3B5 Indirect emission	N_2O	120	81
3.D Agricultural Soils		3 375	35
3.D.1 Direct soil emissions		2 664	40
3.D.1.a Inorganic N fertiliser	N_2O	822	80
3.D.1.b.i Animal manure applied to soils	N_2O	745	84
3.D.1.b.ii Sewage sludge applied to soils	N_2O	21	81
3.D.1.b.iii Other organic fertiliser applied to soils	N_2O	23	82
3.D.1.c Urine and dung deposited by grazing animals	N_2O	25	250
3.D.1.d Crop Residues	N_2O	634	84
3.D.1.e Mineralisation	N_2O	75	94
3.D.1.f Cultivation of organic soils	N_2O	319	64
3.D.2 Indirect soil emissions		711	72
3.D.2.a Atmospheric deposition	N_2O	213	26
3.D.2.b Leaching	N_2O	498	102
3F Field burning of Agricultural residues		3	49
	CH_4	2	56
	N_2O	0.4	56
3G Liming	CO_2	183	100
3H Urea application	CO_2	13	100
3I Other carbon containing fertilisers	CO_2	5	100

15.3 Updating of uncertainties

In the 2026 submission, the uncertainty estimates for some of the emission categories will be reviewed and some corrections will be made. One emission category where the uncertainty for sure will be updated, is for activity data for inorganic N fertiliser and it will be increased, because review of various sources of activity data show differences, which indicate a higher uncertainty than the 3 % used till now.

16 Conclusion

In response to a number of international conventions, Denmark is committed to calculate the Danish emissions to the atmosphere of a range of different pollutants. For the agricultural sector, the emissions includes ammonia (NH_3), the greenhouse gases methane (CH_4), nitrous oxide (N_2O), carbon dioxide (CO_2), the indirect greenhouse gases non-methane volatile organic compounds (NMVOC), particulate matter (PM), nitrogen oxides (NO_x) and a series of other pollutants related to the field burning of crop residues (CO, SO_2, heavy metals, PAHs, dioxins, HCB and PCBs) and HCB from use of pesticides.

DCE - Danish Centre for Environment and Energy is responsible for providing and reporting the annual emission inventories. In addition to the emission inventories themselves, requirements in the various conventions call for documentation of used calculation methodology. This report, therefore, includes a review of the emissions for the period 1985–2023, a description of the main drivers for the emission trend and a description on how the emission is calculated. The report is an updated version of Scientific Report from DCE – Danish Centre for Environment and Energy No. 443 (Albrektsen et al., 2021).

16.1 Agricultural emissions from 1985 to 2023

In 2023, the agricultural sector contributes 95 % of the total NH_3 emission, while the agricultural part of the greenhouse gases is estimated to 29 %. The agricultural emissions are primarily related to livestock production.

The NH_3 emission has decreased from 162 kt NH_3 in 1985 and 63 kt NH_3 in 2023, corresponding to 61 %.

The agricultural emission of greenhouse gases in 2023 is estimated to 11.2 million tonnes CO_2-eqv. and is reduced from 15.3 million tonnes CO_2-eqv. in 1985. Since 1990, which is the base year of the United Nations Framework Convention on Climate Change, where the emission was 14.6 million tonnes CO_2-eqv., a reduction to 2023 of 23 % is obtained.

An active national environmental policy has taken place from the late 1980s onwards, where a string of measures has been introduced by action plans to prevent loss of primarily nitrogen from agriculture to the environment, with a primary focus on losses to the aquatic environment. The improvement of feed efficiency and nitrogen utilisation in manure has led to a significant decrease in consumption of inorganic N fertiliser. Combined with requirements to the handling of animal manure during storage and application, these are the main drivers for the reduction of both the emission of NH_3 and the greenhouse gas N_2O. Furthermore, the decrease in number of cattle and in later years frequent removal of slurry in barns for fattening pigs has led to a reduction in CH_4 emission.

16.2 Methodology and documentation

Preparation of the Danish emission inventories are based on the international guidelines EMEP/EEA air pollutant emission inventory guidebook (EMEP, 2023), 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) and 2019 Refinement to 2006 IPCC Guidelines for National Greenhouse

Gas Inventories (IPCC, 2019). In Denmark, a relatively large amount of data and information is available related to the specific Danish climate and to agricultural production conditions, including livestock populations, barn types, slaughter data, feed intake, N excretion, etc. Where data relevant for Danish agricultural production are not available, standard values recommended in the international guidelines are used.

Data used to calculate the agricultural emissions are collected, assessed and discussed in cooperation with a range of different institutions involved in agricultural related research, advisory services and administration. Especially of relevance are Statistics Denmark, DCA - Danish Centre for Food and Agriculture at Aarhus University and SEGES Innovation (the national agricultural advisory service centre). Furthermore, the following institutions have been involved: the Danish Environmental Protection Agency, Agency for Green Transition and Aquatic Environment, the Danish Agency for Agriculture and Fisheries and the Danish Energy Agency.

Calculation methodology and background data will be continually evaluated and, where necessary, adjusted as part of developments in research on a national scale, as well as on an international scale via changes in the IPCC Guidelines and the EMEP/EEA Guidebook.

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Appendixes

A) Ammonia emissions from Danish agriculture 1985–2023, kt NH_3-N and kt NH_3.

NH_3-N	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Agricultural Sector – total	**133.71**	**131.22**	**128.40**	**124.90**	**125.81**	**126.14**	**121.11**	**116.96**	**114.06**	**109.64**	**103.08**	**98.43**	**97.30**
Manure Management	42.98	43.89	43.03	43.42	43.06	41.35	40.96	41.83	41.16	40.03	38.41	38.23	39.05
Inorganic N fertiliser	24.55	21.12	20.99	19.95	20.79	22.45	21.28	19.23	18.56	18.49	17.30	15.81	15.68
Manure applied to soil	48.84	48.09	45.75	44.40	43.43	43.39	41.24	39.26	37.42	34.35	31.78	30.09	28.77
Grazing animals	3.73	3.63	3.49	3.44	3.42	3.44	3.44	3.39	3.40	3.29	3.29	3.32	3.26
Cultivated crops	4.92	4.92	4.91	4.86	4.84	4.88	4.85	4.82	4.75	4.41	4.35	4.38	4.48
Crop residue	1.76	1.58	1.56	1.78	1.71	1.77	1.68	1.46	1.67	1.61	1.66	1.61	1.63
Sewage sludge used as fertiliser	0.21	0.21	0.22	0.25	0.30	0.33	0.34	0.41	0.53	0.48	0.50	0.49	0.43
NH_3 treated straw	5.40	6.63	7.36	5.98	7.42	8.41	7.13	6.33	6.25	6.68	5.47	4.18	3.69
Field burning of agricultural residue	1.22	1.04	0.98	0.71	0.75	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
Other organic	0.10	0.10	0.10	0.10	0.10	0.10	0.18	0.20	0.30	0.30	0.29	0.31	0.30
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agricultural Sector - total	**96.73**	**91.34**	**88.69**	**85.66**	**82.87**	**79.57**	**79.06**	**76.66**	**73.71**	**72.50**	**72.40**	**68.66**	**69.97**
Manure Management	40.40	39.33	38.70	40.06	40.64	39.95	41.56	39.15	37.16	34.87	34.17	32.96	33.01
Inorganic N fertiliser	14.97	13.92	12.82	11.97	10.94	10.66	11.03	10.83	10.36	10.67	11.31	9.05	10.13
Manure applied to soil	28.10	26.55	25.13	22.01	20.52	18.70	16.76	17.15	16.68	17.65	17.29	16.93	17.27
Grazing animals	3.26	3.21	3.22	3.28	3.18	2.95	2.73	2.60	2.48	2.40	2.39	2.22	2.12
Cultivated crops	4.45	4.33	4.37	4.48	4.55	4.54	4.59	4.65	4.73	4.54	4.78	4.77	4.81
Crop residue	1.72	1.58	1.67	1.65	1.46	1.40	1.34	1.59	1.63	1.65	1.67	1.92	1.85
Sewage sludge used as fertiliser	0.41	0.39	0.39	0.38	0.39	0.37	0.33	0.29	0.33	0.37	0.41	0.38	0.39
NH_3 treated straw	3.05	1.71	2.04	1.34	0.78	0.66	0.43	0.21	0.13	0.13	0.13	0.13	0.13
Field burning of agricultural residue	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
Other organic	0.34	0.29	0.34	0.48	0.40	0.32	0.24	0.16	0.19	0.19	0.23	0.26	0.23

A) *Continued…* kt NH_3-N

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Agricultural Sector - total	**67.05**	**66.05**	**64.28**	**65.33**	**66.01**	**66.79**	**68.15**	**67.06**	**63.59**	**65.35**	**59.28**	**57.21**	**51.91**
Manure Management	32.88	32.32	30.28	30.31	30.17	29.59	29.36	29.50	27.71	27.79	23.52	22.24	20.30
Inorganic N fertiliser	10.58	10.09	10.21	10.77	11.41	12.61	14.07	12.81	11.32	12.35	11.47	11.54	9.54
Manure applied to soil	13.99	13.97	14.30	14.60	14.81	14.92	15.16	15.42	14.95	15.23	14.45	13.77	12.96
Grazing animals	2.04	2.04	2.00	1.94	1.88	1.89	1.88	1.88	1.83	1.96	1.94	1.93	1.86
Cultivated crops	4.82	4.83	4.93	5.04	5.12	5.02	5.02	5.15	5.16	5.28	5.22	5.29	5.21
Crop residue	1.95	1.96	1.69	1.77	1.74	1.85	1.77	1.38	1.56	1.57	1.54	1.45	1.10
Sewage sludge used as fertiliser	0.39	0.40	0.41	0.44	0.43	0.43	0.39	0.44	0.51	0.64	0.54	0.48	0.55
NH_3 treated straw	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.20	0.07	0.01
Field burning of agricultural residue	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.03
Other organic	0.23	0.29	0.31	0.29	0.30	0.33	0.34	0.32	0.38	0.36	0.37	0.40	0.36

A) *Continued…* kt NH_3

NH_3	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Agricultural Sector - total	**162.36**	**159.34**	**155.91**	**151.67**	**152.78**	**153.17**	**147.07**	**142.02**	**138.50**	**133.14**	**125.17**	**119.52**	**118.15**
Manure Management	52.19	53.29	52.25	52.73	52.29	50.21	49.74	50.79	49.98	48.60	46.64	46.43	47.42
Inorganic N fertiliser	29.81	25.65	25.49	24.22	25.24	27.26	25.83	23.35	22.54	22.45	21.01	19.19	19.04
Manure applied to soil	59.31	58.40	55.56	53.92	52.73	52.68	50.07	47.67	45.44	41.71	38.59	36.54	34.93
Grazing animals	4.53	4.41	4.24	4.18	4.16	4.17	4.18	4.12	4.13	3.99	3.99	4.03	3.96
Cultivated crops	5.97	5.97	5.96	5.91	5.88	5.92	5.88	5.85	5.77	5.36	5.28	5.31	5.44
Sewage sludge used as fertiliser	2.13	1.92	1.90	2.16	2.08	2.15	2.03	1.77	2.02	1.95	2.02	1.96	1.98
NH_3 treated straw	0.26	0.26	0.27	0.30	0.36	0.40	0.42	0.50	0.64	0.58	0.60	0.59	0.52
Field burning of agricultural residue	6.55	8.05	8.94	7.26	9.01	10.21	8.66	7.69	7.59	8.12	6.65	5.07	4.49
Other organic	1.48	1.26	1.19	0.87	0.91	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03

A) *Continued…* kt NH_3

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agricultural Sector - total	**117.46**	**110.91**	**107.70**	**104.02**	**100.63**	**96.62**	**96.00**	**93.08**	**89.50**	**88.03**	**87.91**	**83.37**	**84.96**
Manure Management	49.06	47.76	46.99	48.64	49.35	48.51	50.47	47.54	45.12	42.35	41.50	40.02	40.08
Inorganic N fertiliser	18.17	16.90	15.57	14.54	13.28	12.94	13.40	13.15	12.58	12.95	13.73	10.99	12.30
Manure applied to soil	34.13	32.24	30.51	26.73	24.91	22.71	20.36	20.82	20.25	21.43	20.99	20.56	20.97
Grazing animals	3.96	3.90	3.91	3.98	3.87	3.58	3.32	3.16	3.01	2.92	2.90	2.70	2.57
Cultivated crops	5.41	5.25	5.31	5.44	5.52	5.51	5.57	5.64	5.74	5.51	5.80	5.80	5.85
Sewage sludge used as fertiliser	2.09	1.92	2.02	2.00	1.77	1.70	1.63	1.93	1.98	2.00	2.03	2.33	2.25
NH_3 treated straw	0.50	0.48	0.47	0.46	0.47	0.45	0.40	0.35	0.40	0.45	0.49	0.46	0.47
Field burning of agricultural residue	3.71	2.08	2.47	1.62	0.94	0.80	0.53	0.26	0.16	0.16	0.16	0.16	0.16
Other organic	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.04	0.03

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Agricultural Sector - total	**81.41**	**80.21**	**78.06**	**79.32**	**80.16**	**81.10**	**82.75**	**81.43**	**77.21**	**79.35**	**71.99**	**69.47**	**63.03**
Manure Management	39.93	39.25	36.77	36.80	36.64	35.93	35.65	35.82	33.65	33.74	28.57	27.00	24.65
Inorganic N fertiliser	12.85	12.25	12.39	13.08	13.85	15.31	17.08	15.55	13.75	15.00	13.92	14.01	11.58
Manure applied to soil	16.99	16.97	17.37	17.73	17.99	18.12	18.41	18.72	18.15	18.50	17.54	16.72	15.74
Grazing animals	2.48	2.47	2.43	2.36	2.28	2.29	2.29	2.28	2.22	2.39	2.35	2.34	2.26
Cultivated crops	5.86	5.86	5.99	6.12	6.22	6.10	6.09	6.25	6.26	6.42	6.34	6.43	6.32
Sewage sludge used as fertiliser	2.37	2.38	2.06	2.15	2.11	2.24	2.15	1.68	1.90	1.91	1.87	1.76	1.33
NH_3 treated straw	0.48	0.49	0.49	0.54	0.52	0.52	0.48	0.53	0.62	0.77	0.66	0.58	0.67
Field burning of agricultural residue	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.24	0.08	0.01
Other organic	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.04

B) Ammonia emissions from animals 1985–2023, kt NH_3.

		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Cattle	Barn	7.47	7.34	7.04	6.88	6.88	6.94	6.91	6.81	6.77	6.57	6.59	6.59	6.57	6.72
	Storage	5.37	5.26	5.02	4.89	4.86	4.89	4.86	4.77	4.74	4.57	4.58	4.58	4.44	4.42
	Application	38.79	37.39	35.17	33.66	33.02	31.92	30.11	27.99	26.30	24.26	23.06	21.79	20.09	18.98
	Grazing	3.66	3.55	3.38	3.31	3.29	3.32	3.32	3.26	3.28	3.14	3.14	3.14	3.05	3.02
Swine	Barn	21.40	21.98	21.40	21.13	20.53	20.44	20.52	21.10	21.69	20.32	18.95	18.80	19.16	20.14
	Storage	9.97	10.00	9.51	9.17	8.69	8.48	8.30	8.36	8.53	7.90	7.38	7.24	7.34	7.64
	Application	19.08	19.51	18.85	18.55	17.91	19.14	18.39	18.09	17.69	15.85	14.03	13.27	13.32	13.63
	Grazing	0	0	0	0	0	0	0.006	0.015	0.022	0.027	0.035	0.041	0.051	0.062
Poultry	Barn	1.71	1.79	1.91	2.15	2.41	2.42	2.47	2.68	2.83	3.14	3.08	3.04	3.04	2.99
	Storage	0.73	0.75	0.79	0.89	1.02	1.02	1.05	1.12	1.20	1.30	1.25	1.20	1.24	1.25
	Application	0.68	0.69	0.67	0.73	0.78	0.78	0.75	0.77	0.81	0.90	0.80	0.77	0.74	0.71
	Grazing	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.05	0.05	0.05
Other	Barn	4.91	5.48	5.85	6.81	7.07	5.36	4.99	5.30	3.72	4.27	4.27	4.43	5.02	5.29
	Storage	0.63	0.69	0.72	0.81	0.83	0.66	0.62	0.65	0.49	0.54	0.53	0.55	0.60	0.63
	Application	0.75	0.82	0.86	0.98	1.02	0.85	0.82	0.83	0.64	0.70	0.70	0.71	0.78	0.81
	Grazing	0.84	0.85	0.85	0.85	0.85	0.83	0.84	0.83	0.81	0.79	0.79	0.80	0.81	0.82
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cattle	Barn	6.43	6.91	7.16	7.30	7.78	7.92	8.18	8.41	9.00	9.34	9.27	9.28	9.61	9.77
	Storage	4.37	4.74	4.76	4.60	4.44	4.45	2.47	2.54	1.82	1.87	1.84	1.85	1.89	1.92
	Application	17.60	15.64	13.47	12.07	10.38	7.90	8.21	8.49	9.01	9.17	8.97	9.50	7.46	7.79
	Grazing	2.93	2.92	2.97	2.85	2.54	2.25	2.06	1.89	1.79	1.76	1.63	1.57	1.55	1.53
Swine	Barn	19.71	19.39	20.25	21.27	20.71	21.43	20.63	18.73	17.98	16.75	15.70	15.37	15.19	14.42
	Storage	7.45	5.92	6.14	5.60	5.04	5.15	4.28	3.92	2.67	2.42	2.26	2.24	2.18	2.09
	Application	13.16	13.34	11.69	11.25	10.74	10.97	10.97	10.11	10.50	9.84	9.55	9.43	7.89	7.47
	Grazing	0.083	0.084	0.076	0.057	0.056	0.056	0.054	0.052	0.044	0.033	0.030	0.030	0.012	0.025
Poultry	Barn	3.13	3.18	3.22	3.21	3.25	3.43	3.42	2.98	2.93	3.01	2.81	2.90	2.81	2.61
	Storage	1.30	1.29	1.31	1.29	1.33	1.38	1.32	1.15	0.71	0.73	0.68	0.71	0.67	0.67
	Application	0.71	0.68	0.68	0.69	0.71	0.72	0.76	0.70	0.70	0.71	0.66	0.68	0.59	0.58
	Grazing	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.06	0.06
Other	Barn	4.78	5.01	5.25	5.50	5.41	6.17	6.70	6.86	6.87	7.02	7.09	7.37	7.23	7.42
	Storage	0.59	0.56	0.55	0.56	0.54	0.54	0.56	0.53	0.35	0.36	0.36	0.37	0.35	0.35
	Application	0.76	0.86	0.89	0.91	0.88	0.77	0.89	0.95	1.22	1.27	1.38	1.36	1.04	1.13
	Grazing	0.83	0.84	0.88	0.90	0.93	0.95	0.98	1.01	1.03	1.05	0.99	0.92	0.86	0.86

B) *Continued…*

		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Cattle	Barn	9.81	9.64	9.63	9.99	9.33	9.61	9.49	9.46	9.15	9.00	8.69
	Storage	1.93	1.90	1.86	1.96	2.04	2.10	2.11	2.12	2.06	2.04	2.03
	Application	8.06	8.22	8.36	8.66	8.78	8.99	9.00	9.11	9.15	9.00	8.96
	Grazing	1.52	1.46	1.35	1.32	1.27	1.22	1.15	1.11	1.08	1.06	1.01
Swine	Barn	13.99	14.14	13.87	12.78	12.73	12.92	12.15	12.55	12.01	10.88	9.04
	Storage	2.04	2.09	2.00	1.92	1.97	2.03	1.94	1.99	1.92	1.76	1.52
	Application	7.38	7.57	7.56	7.40	7.51	7.68	7.34	7.62	7.46	6.83	5.86
	Grazing	0.024	0.014	0.011	0.013	0.016	0.018	0.027	0.094	0.094	0.096	0.088
Poultry	Barn	1.87	1.75	1.64	1.77	1.69	1.78	1.85	1.84	1.77	1.69	1.70
	Storage	0.67	0.66	0.67	0.71	0.69	0.71	0.71	0.73	0.70	0.66	0.70
	Application	0.58	0.57	0.58	0.61	0.59	0.61	0.62	0.63	0.61	0.57	0.61
	Grazing	0.06	0.06	0.06	0.07	0.08	0.09	0.09	0.09	0.10	0.10	0.09
Other	Barn	5.96	6.03	6.33	6.18	6.56	6.07	4.90	4.57	0.80	0.80	0.81
	Storage	0.49	0.60	0.62	0.62	0.65	0.61	0.51	0.49	0.16	0.16	0.16
	Application	1.34	1.38	1.49	1.46	1.53	1.44	1.19	1.14	0.32	0.32	0.32
	Grazing	0.83	0.83	0.85	0.89	0.92	0.95	0.96	1.08	1.08	1.08	1.07

C) Development in the emission of greenhouse gases, 1985-2023, measured in kt CO_2 equivalents.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
CH_4	7 973	7 866	7 560	7 418	7 380	7 481	7 658	7 803	8 047	7 922	7 972	8 019	7 959
N_2O	6 575	6 473	6 325	6 337	6 390	6 500	6 326	6 171	5 991	5 871	5 749	5 427	5 448
CO_2	728	751	495	734	883	613	507	399	346	409	534	416	482
Total	15 276	15 089	14 379	14 489	14 653	14 594	14 490	14 373	14 383	14 202	14 254	13 862	13 888

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CH_4	8 126	7 906	7 977	8 230	8 301	8 328	8 307	8 167	7 988	8 069	8 000	7 993	8 135
N_2O	5 517	5 304	5 232	5 117	5 090	4 886	4 962	4 887	4 764	4 891	4 910	4 802	4 666
CO_2	263	273	268	206	236	228	160	222	196	194	231	186	156
Total	13 906	13 483	13 477	13 553	13 627	13 442	13 429	13 276	12 948	13 154	13 140	12 982	12 957

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
CH_4	8 090	8 131	8 097	8 133	8 077	8 127	8 103	8 189	7 969	8 026	8 062	7 762	7 140
N_2O	4 680	4 613	4 565	4 659	4 648	4 738	4 763	4 538	4 652	4 683	4 315	4 266	3 881
CO_2	165	192	246	240	176	216	219	244	185	254	267	268	201
Total	12 935	12 936	12 908	13 032	12 901	13 081	13 085	12 971	12 805	12 964	12 644	12 296	11 223

D) Development in the emission of greenhouse gases, 1985-2023, measured in kt CO_2 equivalents, distributed on main sources.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
CH_4													
Enteric fermentation	5 067	4 904	4 637	4 496	4 423	4 455	4 494	4 443	4 511	4 413	4 409	4 406	4 254
Manure management	2 808	2 878	2 844	2 865	2 897	3 024	3 161	3 358	3 534	3 507	3 562	3 611	3 702
Field burning	98	84	79	58	60	2	2	2	2	2	2	2	2
N_2O													
Crop residue	504	507	474	545	571	650	621	476	552	536	622	626	661
Atmospheric deposition - soil	576	555	543	519	527	541	513	482	467	447	417	389	377
Atmospheric deposition - manure management	252	258	253	255	253	243	240	246	242	235	226	225	229
Grazing	65	63	60	59	59	60	60	59	59	57	57	57	56
Manure management	644	664	657	665	671	677	689	714	717	690	671	675	685
Field burning	15	13	12	9	9	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3
Inorganic N fertiliser	1 658	1 591	1 588	1 528	1 570	1 667	1 644	1 539	1 386	1 358	1 315	1 211	1 198
Organic soils	748	742	736	730	724	717	711	705	699	692	686	680	674
Manure on soil	921	923	892	881	872	869	866	870	877	845	822	821	815
Mineralization	160	151	129	189	200	179	121	213	125	102	111	64	86
Sewage sludge	8	8	9	10	12	13	13	16	21	19	19	19	17
Leaching and run-off	1 016	991	966	941	916	878	835	840	828	872	783	642	632
Other organic fertiliser	6	6	6	6	6	6	11	13	19	19	19	19	19
CO_2													
Field burning	881	750	708	516	542	17	17	15	16	16	18	18	19
Liming	696	712	452	694	837	565	463	357	307	367	496	393	470
Urea	10	8	7	9	8	15	12	13	13	18	15	9	4
CAN	22	30	35	31	38	33	32	29	26	23	22	14	8

D) *Continued…*

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CH_4													
Enteric fermentation	4 259	4 094	4 034	4 114	4 052	4 005	3 886	3 873	3 874	3 962	4 001	4 005	4 048
Manure management	3 865	3 809	3 941	4 114	4 248	4 321	4 419	4 292	4 112	4 104	3 996	3 986	4 084
Field burning	2	2	2	2	2	2	2	3	3	2	2	2	2
N_2O													
Crop residue	645	600	657	673	636	658	659	688	682	656	706	790	726
Atmospheric deposition - soil	366	339	326	300	279	263	251	251	243	251	256	240	247
Atmospheric deposition - manure management	237	231	227	235	239	234	244	230	218	205	200	193	194
Grazing	55	54	54	55	53	48	44	41	38	36	36	33	32
Manure management	711	699	697	719	734	724	748	703	652	655	611	573	566
Field burning	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.4	0.3
Inorganic N fertiliser	1 179	1 094	1 047	973	878	838	861	859	799	810	918	884	837
Organic soils	667	661	655	649	642	636	630	624	617	611	605	599	592
Manure on soil	831	821	813	834	857	856	874	883	855	905	887	867	872
Mineralization	70	86	92	53	119	95	70	61	101	149	104	63	32
Sewage sludge	16	15	15	15	15	15	13	11	13	14	16	15	15
Leaching and run-off	717	686	627	579	613	499	554	526	533	587	557	528	540
Other organic fertiliser	21	18	22	30	25	20	15	10	12	12	14	17	14
CO_2													
Field burning	22	21	21	22	19	21	22	22	22	20	19	22	17
Liming	252	265	261	201	233	226	158	220	194	192	229	181	153
Urea	4	3	2	2	1	1	1	0	1	1	0	2	1
CAN	6	5	5	4	2	1	1	1	1	1	2	3	2

D) *Continued…*

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
CH_4													
Enteric fermentation	4 005	4 100	4 129	4 132	4 106	4 164	4 183	4 202	4 151	4 137	4 188	4 099	3 974
Manure management	4 084	4 029	3 966	3 998	3 969	3 961	3 918	3 984	3 815	3 887	3 872	3 660	3 164
Field burning	2	2	2	2	2	2	2	2	3	3	3	3	2
N_2O													
Crop residue	745	758	750	814	802	765	803	599	791	805	752	792	634
Atmospheric deposition - soil	231	228	229	236	241	251	261	253	243	254	241	236	213
Atmospheric deposition - manure management	193	190	178	178	177	174	172	173	163	163	138	131	120
Grazing	31	31	31	30	28	28	28	27	26	27	27	26	25
Manure management	552	542	546	544	537	534	533	544	510	504	464	436	386
Field burning	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.4
Inorganic N fertiliser	861	834	840	858	887	1 020	1 036	943	978	1 049	952	995	822
Organic soils	568	544	520	497	474	452	430	409	388	367	347	327	319
Manure on soil	869	866	873	878	881	889	905	919	884	893	844	804	745
Mineralization	54	46	33	67	32	43	26	112	81	56	37	43	75
Sewage sludge	15	16	16	17	17	17	15	17	20	25	21	18	21
Leaching and run-off	545	541	529	523	552	545	531	522	544	518	467	431	498
Other organic fertiliser	15	18	19	18	19	21	22	20	24	23	24	25	23
CO_2													
Field burning	17	19	20	20	19	18	20	21	24	24	25	27	22
Liming	162	188	244	238	166	212	214	240	181	250	262	246	183
Urea	1	1	1	1	1	2	2	1	1	1	1	16	13
CAN	2	2	2	2	9	3	3	2	3	4	3	6	5

E) Number of livestock.

1) Number of livestock given in AAP (average annual production), thousands.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Dairy cattle	896	864	811	774	759	753	742	712	714	700	702	701	670	669	640	636	623
Non-dairy cattle[1]	1 721	1 631	1 540	1 488	1 462	1 486	1 480	1 478	1 481	1 405	1 388	1 393	1 334	1 308	1 247	1 232	1 284
Sheep	99	131	148	182	208	230	266	256	221	200	202	235	240	252	264	279	297
Goats	8	8	8	8	8	7	7	7	7	7	7	7	7	8	8	8	9
Horses	140	139	138	137	136	135	137	138	140	141	143	144	146	147	149	150	155
Sows	928	949	923	901	883	904	928	1 001	1 041	992	1 015	1 010	1 068	1 092	1 061	1 083	1 121
Weaners	4 734	4 877	4 833	4 796	4 745	4 881	4 995	5 304	5 690	5 514	5 613	5 511	5 804	5 352	5 189	5 330	5 669
Fattening pigs	3 427	3 494	3 510	3 521	3 562	3 712	3 859	4 150	4 837	4 417	4 456	4 320	4 511	5 651	5 376	5 508	5 818
Poultry[2]	15 219	15 220	15 540	15 524	17 194	16 249	15 933	19 041	19 898	19 852	19 619	19 888	18 994	18 674	21 010	21 830	21 236
Fur animals	1 906	2 194	2 402	2 877	3 055	2 264	2 112	2 283	1 537	1 828	1 850	1 918	2 212	2 345	2 089	2 199	2 304
Pheasant	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063
Deer	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11
Ostrich	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	2.2	3.3	4.4	5.6	6.7	7.8	8.9	10.0

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dairy cattle	610	596	563	564	550	545	558	563	568	565	587	582	563	561	572	570	575
Non-dairy cattle[1]	1 187	1 128	1 082	1 006	984	1 021	1 006	977	1 003	1 003	1 020	1 032	1 001	991	997	975	965
Sheep	294	303	310	316	319	309	294	289	278	234	226	221	220	210	207	204	205
Goats	9	10	11	11	12	13	14	16	16	13	13	13	12	11	11	11	10
Horses	160	165	170	175	180	185	190	178	165	155	155	150	150	155	163	170	175
Sows	1 128	1 149	1 155	1 151	1 127	1 148	1 059	1 088	1 117	1 063	1 011	977	1 032	1 034	999	1 014	1 045
Weaners	5 771	5 917	6 016	6 165	6 142	6 268	5 893	5 882	6 166	6 061	5 847	5 736	5 995	6 196	6 072	6 116	6 391
Fattening pigs	5 833	5 883	6 061	6 218	6 092	6 307	5 785	5 399	5 890	5 809	5 473	5 363	5 305	5 308	5 312	5 178	5 345
Poultry[2]	20 580	17 844	16 649	17 633	17 425	16 741	15 406	19 676	18 731	19 319	18 991	19 431	18 348	17 523	18 503	21 484	19 973
Fur animals	2 422	2 361	2 471	2 552	2 708	2 837	2 810	2 721	2 699	2 757	2 948	3 123	3 308	3 388	3 251	3 416	3 363
Pheasant	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063
Deer	10	10	10	10	10	10	10	9	10	8	7	8	7	8	7	7	8
Ostrich	6.6	4.8	4.2	3.7	3.7	0.6	0.5	0.4	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1

[1]Non-dairy cattle include calves, bulls, heifers and suckling cows

[2]Poultry includes hens, pullets, broilers, turkeys, ducks and geese

E) *Continued…*

1) *Continued…*

	2019	2020	2021	2022	2023
Dairy cattle	567	567	564	557	547
Non-dairy cattle[1]	925	932	924	914	895
Sheep	220	200	196	190	186
Goats	12	10	10	10	11
Horses	175	183	183	183	180
Sows	1 002	1 055	1 042	975	911
Weaners	6 150	6 576	6 544	6 216	5 568
Fattening pigs	5 147	5 532	5 583	5 182	4 344
Poultry[2]	23 060	22 133	21 892	23 058	22 634
Fur animals	2 466	2 216	0	0	6
Pheasant	1 063	1 063	1 063	1 063	1 063
Deer	8	7	7	6	5
Ostrich	0.1	0.1	0.1	0.1	0.1

[1]Non-dairy cattle include calves, bulls, heifers and suckling cows

[2]Poultry includes hens, pullets, broilers, turkeys, ducks and geese

2) Number of livestock given in produced number of animals, thousands.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Dairy cattle	896	864	811	774	759	753	742	712	714	700	702	701	670	669	640	636	623
Non-dairy cattle[1]	3 312	3 178	2 992	2 884	2 805	2 854	2 861	2 885	2 805	2 689	2 676	2 643	2 545	2 462	2 337	2 274	2 286
Sheep	99	131	148	182	208	230	266	256	221	200	202	235	240	252	264	279	297
Goats	8	8	8	8	8	7	7	7	7	7	7	7	7	8	8	8	9
Horses	140	139	138	137	136	135	137	138	140	141	143	144	146	147	149	150	155
Sows	928	949	923	901	883	904	928	1 001	1 041	992	1 015	1 010	1 068	1 092	1 061	1 083	1 121
Weaners	14 633	15 464	15 468	15 757	15 724	16 472	17 477	18 948	20 842	21 055	20 885	21 133	22 013	24 091	24 090	23 749	24 831
Fattening pigs	14 633	15 464	15 468	15 757	15 724	16 470	17 454	18 889	20 793	20 944	20 643	20 750	21 315	22 926	22 900	22 571	23 719
Poultry[2]	94 078	93 400	92 711	99 465	106 678	108 640	113 682	123 520	129 498	139 644	135 907	129 306	132 410	139 230	150 255	146 854	149 102
Fur animals	1 906	2 194	2 402	2 877	3 055	2 264	2 112	2 283	1 537	1 828	1 850	1 918	2 212	2 345	2 089	2 199	2 304
Pheasant	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Deer	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11
Ostrich	0	0	0	0	0	0	0	0	1.1	2.2	3.3	4.4	5.6	6.7	7.8	8.9	10.0

[1]Non-dairy cattle include calves, bulls, heifers and suckling cows

[2]Poultry includes hens, pullets, broilers, turkeys, ducks and geese

E) *Continued…*

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dairy cattle	610	596	563	564	550	545	558	563	568	565	587	582	563	561	572	570	575
Non-dairy cattle[1]	2 220	1 373	1 359	1 246	1 210	1 261	1 267	1 212	1 224	1 257	1 220	1 238	1 211	1 197	1 194	1 176	1 170
Sheep	294	303	310	316	319	309	294	289	278	234	226	221	220	210	207	204	205
Goats	9	10	11	11	12	13	14	16	16	13	13	13	12	11	11	11	10
Horses	160	165	170	175	180	185	190	178	165	155	155	150	150	155	163	170	175
Sows	1 128	1 149	1 155	1 151	1 127	1 148	1 059	1 088	1 117	1 063	1 011	977	1 032	1 034	999	1 014	1 045
Weaners	25 913	26 037	27 058	26 940	27 058	27 518	27 690	28 088	29 202	29 941	29 578	29 694	30 596	31 493	32 378	32 267	33 180
Fattening pigs	24 302	24 341	25 150	23 944	23 340	23 548	22 303	21 046	21 618	21 821	20 323	20 134	19 921	19 849	19 541	18 543	19 201
Poultry[2]	148 781	143 256	144 001	135 205	117 875	118 681	120 860	119 414	128 783	128 145	123 559	126 203	123 870	123 519	131 247	127 725	133 134
Fur animals	2 422	2 361	2 471	2 552	2 708	2 837	2 810	2 721	2 699	2 757	2 948	3 123	3 308	3 388	3 251	3 416	3 363
Pheasant	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Deer	10	10	10	10	10	10	10	9	10	8	7	8	7	8	7	7	8
Ostrich	6.6	4.8	4.2	3.7	3.7	0.6	0.5	0.4	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1

	2019	2020	2021	2022	2023
Dairy cattle	567	567	564	557	547
Non-dairy cattle[1]	1 130	1 121	1 109	1 087	1 049
Sheep	220	200	196	190	186
Goats	12	10	10	10	11
Horses	175	183	183	183	180
Sows	1 002	1 055	1 042	975	911
Weaners	32 566	33 217	34 056	32 447	29 900
Fattening pigs	18 154	19 003	20 246	18 868	15 332
Poultry[2]	135 752	132 326	129 634	125 268	128 722
Fur animals	2 466	2 216	0	0	6
Pheasant	2	2	2	2	2
Deer	8	7	7	6	5
Ostrich	0.1	0.1	0.1	0.1	0.1

[1]Non-dairy cattle include calves, bulls, heifers and suckling cows

[2]Poultry includes hens, pullets, broilers, turkeys, ducks and geese

F) Barn type distribution in percent, 1985-2023.

<u>Cattle:</u>

Dairy cattle:

Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Tethered with urine and solid manure	Urine and solid	40.0	39.1	38.2	37.3	36.4	35.5	34.5	33.6	32.7	31.8	30.9	30.0	30.0	30.0	30.0
Tethered with slurry	Slurry	45.0	44.7	44.5	44.2	43.9	43.6	43.4	43.1	42.8	42.5	42.3	42.0	36.0	30.0	30.0
Loose-housing with cubicles, solid floor	Slurry	4.0	3.9	3.8	3.7	3.6	3.6	3.5	3.4	3.3	3.2	3.1	3.0	3.0	3.0	3.0
Loose-housing with cubicles, slatted floor	Slurry	9.0	9.8	10.6	11.5	12.3	13.1	13.9	14.7	15.5	16.4	17.2	18.0	21.0	24.0	24.0
Loose-housing with cubicles, slatted floor, scrape	Slurry	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	3.0
Loose-housing with cubicles, drained floor	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loose-housing with cubicles, solid floor with tilt	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep litter (all)	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep litter, long eating space, solid floor	Deep litter and slurry	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.5	2.0	2.0
Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	0.5	0.9	1.3	1.7	2.1	2.5	2.9	3.4	3.8	4.2	4.6	5.0	6.3	7.5	7.5
Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.5	0.5

Barn type	Manure types	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Tethered with urine and solid manure	Urine and solid	18.0	15.0	12.0	8.0	6.0	6.2	6.4	6.7	5.6	4.8	4.8	3.8	3.3	3.0	2.8
Tethered with slurry	Slurry	28.0	25.0	23.0	18.0	16.0	14.0	12.0	10.0	8.6	7.4	7.4	5.9	5.3	5.2	4.3
Loose-housing with cubicles, solid floor	Slurry	6.0	9.0	11.0	16.0	17.0	15.8	14.6	13.4	13.7	14.1	14.1	15.5	15.3	14.1	15.0
Loose-housing with cubicles, slatted floor	Slurry	34.0	36.0	39.0	42.0	44.0	43.4	42.9	42.3	43.6	44.5	44.5	45.6	45.9	47.4	46.6
Loose-housing with cubicles, slatted floor, scrape	Slurry	3.0	4.0	4.0	5.0	6.0	10.6	15.3	19.9	20.3	20.8	20.8	21.3	21.5	21.7	21.5
Loose-housing with cubicles, drained floor	Slurry	0	0	0	0	0	0	0	0.1	0.4	0.3	0	0	0	0	0
Loose-housing with cubicles, solid floor with tilt	Slurry	0	0	0	0	0	0	0	0.6	1.3	2.1	2.4	2.6	3.3	2.7	4.0
Deep litter (all)	Deep litter	0	0	0	0	0	0.9	1.8	2.0	2.0	2.0	2.0	2.1	2.4	2.7	3.0
Deep litter, long eating space, solid floor	Deep litter and slurry	3.0	3.0	3.0	3.0	3.0	2.3	1.7	1.0	0.8	0.8	0.8	0.7	0.6	0.7	0.6
Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	7.0	7.0	7.0	7.0	7.0	5.4	3.8	2.2	2.1	1.8	1.8	1.5	1.4	1.5	1.3
Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	1.0	1.0	1.0	1.0	1.0	1.4	1.5	1.8	1.6	1.4	1.4	1.0	1.0	1.0	0.9

F) *Continued…*

Dairy cattle:

Barn type	Manure types	2015	2016	2017	2018	2019	2020	2021	2022	2023
Tethered with urine and solid manure	Urine and solid	2.6	2.4	2.0	1.7	1.5	1.4	1.2	1.0	0.8
Tethered with slurry	Slurry	4.0	3.5	3.0	2.6	2.4	2.0	1.8	1.5	1.1
Loose-housing with cubicles, solid floor	Slurry	15.2	14.9	14.9	15.5	15.9	15.9	16.4	16.7	16.8
Loose-housing with cubicles, slatted floor	Slurry	46.2	45.9	46.1	45.8	45.4	44.9	44.1	43.7	43.8
Loose-housing with cubicles, slatted floor, scrape	Slurry	21.4	21.9	21.5	21.7	21.5	21.8	21.6	21.2	20.8
Loose-housing with cubicles, drained floor	Slurry	0	0	0	0	0	0	0	0	0
Loose-housing with cubicles, solid floor with tilt	Slurry	4.4	4.7	5.3	5.4	5.7	5.9	5.9	6.6	6.9
Deep litter (all)	Deep litter	3.4	4.0	4.4	4.7	4.9	5.5	6.4	6.7	7.3
Deep litter, long eating space, solid floor	Deep litter and slurry	0.5	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	1.4	1.2	1.3	1.2	1.2	1.2	1.2	1.2	1.1
Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	0.9	0.9	0.8	0.8	0.9	0.8	0.8	0.8	0.8

F) *Continued…*

Heifers:

Calves, 0-6 mth	Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Deep litter (boxes)	Deep litter	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	Deep litter, solid floor	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Deep litter (boxes)	Deep litter	100	89.0	84.0	83.0	80.0	85.4	90.8	96.2	96.3	96.4	96.4	96.4	96.4	96.9	96.4
	Deep litter, solid floor	Deep litter	0	11.0	16.0	17.0	20.0	14.6	9.2	3.8	3.7	3.6	3.6	3.6	3.6	3.1	3.6
			2015	2016	2017	2018	2019	2020	2021	2022	2023						
	Deep litter (boxes)	Deep litter	96.4	96.6	96.6	96.5	96.7	96.6	96.7	96.9	97.1						
	Deep litter, solid floor	Deep litter	3.6	3.4	3.4	3.5	3.3	3.4	3.3	3.1	2.9						

6 mth-calving	Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Slatted floor-boxes	Slurry	45.0	44.0	43.0	42.0	41.0	40.0	39.0	38.0	37.0	36.0	35.0	34.0	33.0	33.0	32.0
	Tethered with urine and solid manure	Urine and solid	25.0	23.9	22.7	21.5	20.4	19.2	18.1	16.9	15.8	14.6	13.5	12.0	11.0	10.0	10.0
	Tethered with slurry	Slurry	25.0	23.9	22.7	21.5	20.4	19.2	18.1	16.9	15.8	14.6	13.5	12.0	11.0	10.0	10.0
	Loose-housing with cubicles, solid floor	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Loose-housing with cubicles, slatted floor	Slurry	0	0.7	1.5	2.2	2.9	4.0	4.4	5.2	5.9	6.7	7.4	8.0	10.0	12.0	13.0
	Loose-housing with cubicles, slatted floor, scrape	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Loose-housing with cubicles, solid floor with tilt	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Boxes with sloping bedded floor	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Deep litter (all)	Deep litter	5.0	4.6	4.2	3.9	3.5	3.1	2.7	2.3	1.9	1.5	1.1	1.0	0	0	0
	Deep litter, long eating space, solid floor	Deep litter and slurry	0	0.3	0.5	0.7	1.0	1.2	1.5	1.7	1.9	2.2	2.4	3.0	3.0	3.0	3.0
	Deep litter, short eating space, solid floor	Deep litter	0	1.8	3.7	5.6	7.4	9.0	11.1	12.9	14.8	16.6	18.5	22.0	24.0	24.0	24.0
	Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	0	0.7	1.5	2.2	2.9	3.7	4.4	5.2	5.9	6.7	7.4	7.0	7.0	6.0	6.0
	Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	0	0.1	0.2	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.2	1.0	1.0	2.0	2.0

F) *Continued…*

Heifers:

6 mth-calving	Barn type	Manure types	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Slatted floor-boxes	Slurry	32.0	31.0	30.0	30.0	29.0	32.4	35.8	39.2	37.4	34.9	35.0	31.3	29.8	28.7	27.2
	Tethered with urine and solid manure	Urine and solid	9.0	8.0	7.0	7.0	5.0	5.7	6.5	7.2	6.3	5.7	5.7	4.6	4.1	3.8	3.3
	Tethered with slurry	Slurry	9.0	8.0	7.0	7.0	5.0	4.1	3.3	2.4	2.2	2.2	2.2	1.7	1.6	1.5	1.3
	Loose-housing with cubicles, solid floor	Slurry	0	0	0	0	0	1.6	3.1	4.7	5.7	6.3	6.3	6.8	7.1	6.9	7.6
	Loose-housing with cubicles, slatted floor	Slurry	14.0	17.0	20.0	21.0	23.0	19.3	15.7	12.0	13.8	16.2	16.2	19.0	20.4	21.2	22.2
	Loose-housing with cubicles, slatted floor, scrape	Slurry	0	0	0	0	0	1.7	3.4	5.1	5.6	6.4	6.4	7.2	7.7	7.4	8.5
	Loose-housing with cubicles, solid floor with tilt	Slurry	0	0	0	0	0	0	0	0	0	0	0	1.0	1.4	1.8	1.7
	Boxes with sloping bedded floor	Deep litter	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0
	Deep litter (all)	Deep litter	0	0	0	0	0	7.6	15.3	22.9	22.4	21.9	21.9	21.4	21.2	22.3	21.6
	Deep litter, long eating space, solid floor	Deep litter and slurry	3.0	3.0	3.0	3.0	3.0	2.6	2.2	1.8	1.9	1.6	1.6	1.8	1.7	1.5	1.5
	Deep litter, short eating space, solid floor	Deep litter	25.0	26.0	26.0	26.0	28.0	19.0	9.9	0.9	0.9	0.8	0.8	0.9	1.0	0.6	0.8
	Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	6.0	5.0	5.0	5.0	5.0	3.9	2.8	1.8	1.8	1.8	1.8	1.7	1.6	1.8	1.7
	Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	2.0	2.0	2.0	1.0	2.0	2.0	1.9	1.9	1.9	2.1	2.1	2.6	2.4	2.5	2.6

F) *Continued…*

Heifers:

6 mth-calving	Barn type	Manure types	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Slatted floor-boxes	Slurry	25.2	24.0	22.0	20.3	19.6	18.5	17.1	15.9	14.7
	Tethered with urine and solid manure	Urine and solid	3.0	2.6	2.4	2.1	1.8	1.6	1.4	1.3	1.0
	Tethered with slurry	Slurry	1.2	1.3	1.1	1.0	0.9	0.9	0.6	0.6	0.5
	Loose-housing with cubicles, solid floor	Slurry	7.7	8.1	8.6	8.8	8.5	8.7	8.9	9.5	9.5
	Loose-housing with cubicles, slatted floor	Slurry	24.2	25.4	25.8	27.6	28.2	29.2	29.5	30.0	31.2
	Loose-housing with cubicles, slatted floor, scrape	Slurry	9.2	9.0	9.5	9.5	9.9	10.2	10.7	10.2	10.0
	Loose-housing with cubicles, solid floor with tilt	Slurry	1.9	1.9	2.6	2.6	2.6	2.8	3.0	3.1	3.4
	Boxes with sloping bedded floor	Deep litter	0	0	0	0	0	0	0	0	0
	Deep litter (all)	Deep litter	21.5	21.9	22.1	22.1	22.2	22.1	22.7	23.4	23.5
	Deep litter, long eating space, solid floor	Deep litter and slurry	1.4	1.4	1.5	1.6	1.6	1.6	1.3	1.4	1.7
	Deep litter, short eating space, solid floor	Deep litter	0.8	0.8	0.9	0.9	1.0	0.9	1.0	1.0	0.9
	Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	1.8	1.7	1.8	1.5	1.6	1.5	1.7	1.7	1.7
	Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	2.1	1.9	1.7	2.0	2.1	2.0	2.1	1.9	1.9

F) *Continued…*

Bulls:

Calves, 0-6 mth	Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Deep litter (boxes)	Deep litter	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	Deep litter, solid floor	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Deep litter (boxes)	Deep litter	100	90.9	86.0	82.0	77.0	83.6	90.2	96.8	97.1	97.0	97.0	96.7	96.9	97.5	96.9
	Deep litter, solid floor	Deep litter	0	9.1	14.0	18.0	23.0	16.4	9.8	3.2	2.9	3.0	3.0	3.3	3.1	2.5	3.1
			2015	2016	2017	2018	2019	2020	2021	2022	2023						
	Deep litter (boxes)	Deep litter	96.5	96.5	96.6	96.2	95.9	95.9	95.5	95.6	95.6						
	Deep litter, solid floor	Deep litter	3.5	3.5	3.4	3.8	4.1	4.1	4.5	4.4	4.4						

6 mth-440 kg	Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Slatted floor-boxes	Slurry	45.0	44.2	43.5	42.7	41.9	41.2	40.4	39.6	38.9	38.1	37.3	36.5	35.8	35.0	34.0
	Tethered with urine and solid manure	Urine and solid	25.0	23.9	22.9	21.8	20.7	19.6	18.5	17.5	16.4	15.3	14.2	13.2	12.1	11.0	11.0
	Tethered with slurry	Slurry	25.0	23.9	22.9	21.8	20.7	19.6	18.5	17.5	16.4	15.3	14.2	13.2	12.1	11.0	11.0
	Loose-housing with cubicles, solid floor	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Loose-housing with cubicles, slatted floor	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Loose-housing with cubicles, slatted floor, scrape	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Loose-housing with cubicles, solid floor with tilt	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Boxes with sloping bedded floor	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Deep litter (all)	Deep litter	5.0	4.6	4.2	3.8	3.5	3.1	2.7	2.3	1.9	1.5	1.2	0.8	0.4	0	0
	Deep litter, long eating space, solid floor	Deep litter and slurry	0	0.3	0.5	0.8	1.1	1.3	1.6	1.9	2.1	2.4	2.7	2.9	3.2	3.0	3.0
	Deep litter, short eating space, solid floor	Deep litter	0	2.0	4.1	6.1	8.1	10.2	12.3	14.2	16.3	18.4	20.4	22.4	24.5	27.0	29.0
	Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	0	0.9	1.6	2.5	3.4	4.2	5.1	5.9	6.8	7.6	8.5	9.3	10.1	11.0	10.0
	Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	0	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.8	2.0	2.0

F) *Continued…*

Bulls:

6 mth-440 kg	Barn type	Manure types	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Slatted floor-boxes	Slurry	33.0	32.0	31.0	30.0	28.0	28.8	29.6	30.4	29.7	27.3	27.3	24.9	23.3	21.6	20.7
	Tethered with urine and solid manure	Urine and solid	10.0	9.0	8.0	8.0	7.0	6.0	5.0	4.0	3.7	3.1	3.1	2.5	2.3	2.1	1.8
	Tethered with slurry	Slurry	10.0	9.0	8.0	8.0	7.0	5.0	3.0	1.0	0.8	0.8	0.8	0.8	0.6	0.6	0.5
	Loose-housing with cubicles, solid floor	Slurry	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.2	0.3
	Loose-housing with cubicles, slatted floor	Slurry	0	0	0	0	0	0	0	0	0	0.2	0.2	2.6	4.8	8.2	6.1
	Loose-housing with cubicles, slatted floor, scrape	Slurry	0	0	0	0	0	0	0	0	0	0	0	2.8	3.3	4.0	4.1
	Loose-housing with cubicles, solid floor with tilt	Slurry	0	0	0	0	0	0	0	0	0	0	0	0.5	0.6	0.2	1.1
	Boxes with sloping bedded floor	Deep litter	0	0	0	0	0	0	0.1	0.1	0.3	0.1	0	0	0	0	0
	Deep litter (all)	Deep litter	0	0	0	0	0	18.9	37.8	56.6	57.5	60.3	60.4	58.0	57.3	56.8	58.4
	Deep litter, long eating space, solid floor	Deep litter and slurry	3.0	3.0	3.0	3.0	3.0	2.3	1.6	0.9	0.9	1.1	1.1	0.9	1.2	1.1	1.1
	Deep litter, short eating space, solid floor	Deep litter	33.0	37.0	41.0	45.0	48.0	33.6	19.1	4.7	4.4	4.2	4.2	3.8	3.4	3.4	3.0
	Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	9.0	8.0	7.0	5.0	6.0	4.4	2.7	1.1	1.4	1.6	1.6	1.4	1.2	1.1	1.2
	Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	2.0	2.0	2.0	1.0	1.0	1.0	1.1	1.2	1.3	1.3	1.3	1.7	1.9	0.7	1.7

F) *Continued…*

Bulls:

6 mth-440 kg	Barn type	Manure types	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Slatted floor-boxes	Slurry	21.2	19.8	18.9	18.4	17.2	15.4	16.3	15.3	14.4
	Tethered with urine and solid manure	Urine and solid	1.7	1.4	1.3	1.1	0.9	0.9	0.8	0.7	0.6
	Tethered with slurry	Slurry	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2
	Loose-housing with cubicles, solid floor	Slurry	0.9	1.4	3.1	4.2	3.9	3.6	4.8	4.2	4.7
	Loose-housing with cubicles, slatted floor	Slurry	6.2	7.5	8.8	10.5	10.0	10.3	8.1	9.2	10.1
	Loose-housing with cubicles, slatted floor, scrape	Slurry	2.8	2.7	2.7	3.2	3.3	3.7	5.1	5.0	4.7
	Loose-housing with cubicles, solid floor with tilt	Slurry	1.0	1.1	1.0	1.2	1.4	1.6	1.8	1.9	1.9
	Boxes with sloping bedded floor	Deep litter	0	0	0	0	0	0	0	0	0
	Deep litter (all)	Deep litter	57.9	58.4	56.6	54.6	56.4	58.0	56.8	57.5	57.3
	Deep litter, long eating space, solid floor	Deep litter and slurry	1.4	1.4	1.5	1.4	1.1	0.8	0.8	0.9	0.6
	Deep litter, short eating space, solid floor	Deep litter	3.3	2.2	2.3	2.4	2.6	2.5	2.6	2.6	2.9
	Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	1.3	1.7	2.1	1.6	1.8	1.4	1.3	0.9	0.8
	Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	1.8	2.0	1.4	1.1	1.1	1.6	1.4	1.6	1.8

F) *Continued…*

Suckling cows:

Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Tethered with urine and solid manure	Urine and solid	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Tethered with slurry	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loose-housing with cubicles, slatted floor	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loose-housing with cubicles, slatted floor, scrape	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loose-housing with cubicles, solid floor with tilt	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep litter (all)	Deep litter	90.0	86.5	83.1	79.6	76.2	72.7	69.2	65.8	62.3	58.8	55.4	51.9	48.5	45.0	45.0
Deep litter, long eating space, solid floor	Deep litter and slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep litter, short eating space, solid floor	Deep litter	0	3.5	6.9	10.4	13.8	17.3	20.8	24.2	27.7	31.2	34.6	38.1	41.5	45.0	45.0
Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boxes with sloping bedded floor	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Tethered with urine and solid manure	Urine and solid	9.0	8.0	7.0	4.0	5.0	9.2	13.5	17.7	16.0	14.9	14.9	13.4	12.6	12.0	11.1
Tethered with slurry	Slurry	0	0	0	0	0	3.1	6.3	9.4	9.2	8.6	8.6	9.7	8.9	8.2	7.6
Loose-housing with cubicles, slatted floor	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loose-housing with cubicles, slatted floor, scrape	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loose-housing with cubicles, solid floor with tilt	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep litter (all)	Deep litter	45.0	44.0	43.0	44.0	43.0	50.7	58.4	66.1	67.8	68.5	69.1	68.8	70.5	72.9	73.2
Deep litter, long eating space, solid floor	Deep litter and slurry	0	0	0	0	0	0.4	0.9	1.3	1.2	1.4	1.4	1.2	1.3	1.2	1.1
Deep litter, short eating space, solid floor	Deep litter	46.0	48.0	50.0	52.0	52.0	35.3	18.6	1.9	2.2	2.7	2.7	2.7	2.8	2.6	2.8
Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	0	0	0	0	0	0.5	0.9	1.4	1.3	1.5	1.5	1.9	1.7	1.1	1.7
Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	0	0	0	0	0	0.5	1.0	1.5	1.5	1.8	1.8	2.3	2.2	2.0	2.5
Boxes with sloping bedded floor	Deep litter	0	0	0	0	0	0.3	0.4	0.7	0.8	0.6	0	0	0	0	0

F) *Continued…*

Suckling cows:

Barn type	Manure types	2015	2016	2017	2018	2019	2020	2021	2022	2023
Tethered with urine and solid manure	Urine and solid	10.4	9.9	9.2	8.6	8.2	7.7	7.2	6.7	6.0
Tethered with slurry	Slurry	6.9	6.3	6.4	6.3	6.0	5.3	5.0	4.7	4.0
Loose-housing with cubicles, slatted floor	Slurry	0.2	0.5	0.6	0.7	1.1	1.4	1.6	1.6	1.5
Loose-housing with cubicles, slatted floor, scrape	Slurry	0.3	0.6	0.7	0.8	0.7	0.9	0.7	1.0	0.9
Loose-housing with cubicles, solid floor with tilt	Slurry	0	0	0	0	0	0	0	0.3	0.2
Deep litter (all)	Deep litter	74.0	73.9	74.5	74.9	75.4	75.9	77.0	77.3	80.2
Deep litter, long eating space, solid floor	Deep litter and slurry	1.3	1.4	1.3	1.3	1.4	1.4	1.5	1.6	1.3
Deep litter, short eating space, solid floor	Deep litter	2.8	2.9	3.1	3.1	3.1	3.2	3.1	2.7	2.0
Deep litter, long eating space, slatted floor, slurry channels	Deep litter and slurry	1.7	2.1	1.9	1.9	1.7	1.8	1.6	1.7	1.9
Deep litter, long eating space, slatted floor, scraper	Deep litter and slurry	2.4	2.4	2.3	2.4	2.4	2.4	2.3	2.4	2.0
Boxes with sloping bedded floor	Deep litter	0	0	0	0	0	0	0	0	0

F) *Continued…*

Swine:

Sows:

Gestation Period	Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Group-housing, deep litter + solid floor	Deep litter and slurry	0	0.1	0.2	0.3	0.4	0.5	0.6	1.4	2.1	2.8	3.5	4.3	5.0	5.7	6.4
	Group-housing, deep litter + slatted floor	Deep litter and slurry	0	0.1	0.2	0.3	0.4	0.5	0.6	1.4	2.1	2.8	3.5	4.3	5.0	5.7	6.4
	Group-housing, deep litter	Deep litter	5.0	5.4	5.8	6.2	6.6	7.0	7.4	7.7	8.2	8.6	9.7	10.7	11.8	12.8	13.9
	Group-housing, partly slatted floor	Slurry	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Individual housing, partly slatted floor	Slurry	49.6	50.8	52.0	53.1	54.3	55.5	56.6	56.5	56.4	56.2	55.9	55.6	55.3	55.0	54.7
	Individual housing, fully slatted floor	Slurry	1.8	2.4	3.0	3.6	4.3	4.9	5.5	6.1	6.7	7.4	8.0	8.5	9.1	9.8	10.4
	Individual housing, solid floor	Urine and solid	43.6	41.2	38.8	36.5	34.0	31.6	29.3	26.9	24.5	22.2	19.4	16.6	13.8	11.0	8.2
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Group-housing, deep litter + solid floor	Deep litter and slurry	7.7	9.0	9.9	11.1	11.1	7.8	4.6	1.3	1.1	0.9	0.9	1.3	1.2	1.0	1.0
	Group-housing, deep litter + slatted floor	Deep litter and slurry	8.3	9.6	11.7	13.5	13.5	12.2	10.9	9.6	9.0	8.6	8.6	8.6	8.2	8.2	7.8
	Group-housing, deep litter	Deep litter	14.3	14.7	14.9	15.2	15.2	11.2	7.1	3.1	2.8	2.5	2.5	2.0	1.9	2.2	1.9
	Group-housing, partly slatted floor	Slurry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	5.4	8.0	8.0	10.7	13.6	16.2	21.3
	Individual housing, partly slatted floor	Slurry	51.1	49.4	46.7	44.0	44.0	54.0	64.0	71.1	70.4	69.0	69.0	67.5	65.8	62.6	59.7
	Individual housing, fully slatted floor	Slurry	10.4	10.1	10.0	9.8	9.8	9.8	9.7	9.7	9.7	10.0	10.0	9.7	9.1	9.6	8.1
	Individual housing, solid floor	Urine and solid	8.2	7.2	6.8	6.4	6.4	5.0	3.7	2.3	1.6	1.0	1.0	0.2	0.2	0.2	0.2
			2015	2016	2017	2018	2019	2020	2021	2022	2023						
	Group-housing, deep litter + solid floor	Deep litter and slurry	0.8	0.8	0.9	0.7	0.7	0.6	0.6	0.6	0.5						
	Group-housing, deep litter + slatted floor	Deep litter and slurry	7.5	7.3	7.3	6.8	6.1	5.6	5.4	4.9	4.4						
	Group-housing, deep litter	Deep litter	1.9	1.9	1.8	2.5	2.0	1.4	1.5	1.5	1.4						
	Group-housing, partly slatted floor	Slurry	23.6	27.2	30.3	31.8	33.0	33.8	34.9	35.7	36.3						
	Individual housing, partly slatted floor	Slurry	58.0	55.3	59.5	57.9	57.9	58.3	57.4	57.1	57.1						
	Individual housing, fully slatted floor	Slurry	8.0	7.4	0	0	0	0	0	0	0						
	Individual housing, solid floor	Urine and solid	0.2	0.1	0.2	0.3	0.3	0.3	0.2	0.2	0.3						

F) *Continued…*

Sows:

Farrow period	Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Individual housing, partly slatted floor	Slurry	50.0	51.3	52.7	54.0	55.3	56.7	58.0	59.5	61.0	62.5	64.0	65.5	67.0	68.5	70.0
	Individual housing, fully slatted floor	Slurry	5.0	7.5	10.0	12.5	15.0	17.5	20.0	20.6	21.3	21.9	22.5	23.1	23.8	24.4	25.0
	Group-housing, solid floor	Urine and solid	45.0	41.2	37.3	33.5	29.7	25.8	22.0	19.9	17.7	15.6	13.5	11.4	9.2	7.1	5.0
	Group-housing, partly slatted floor	Slurry and solid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Individual housing, partly slatted floor	Slurry	71.0	74.0	74.9	76.6	76.6	76.8	77.0	77.2	78.1	76.9	79.6	80.0	80.9	80.1	81.3
	Individual housing, fully slatted floor	Slurry	24.0	22.0	20.9	19.5	19.5	19.2	19.0	18.7	18.6	19.7	20.4	20.0	19.1	19.9	18.7
	Group-housing, solid floor	Urine and solid	5.0	4.0	4.2	3.9	3.9	3.1	2.2	1.4	0.9	0.7	0	0	0	0	0
	Group-housing, partly slatted floor	Slurry and solid	0	0	0	0	0	0.9	1.8	2.7	2.4	2.7	0	0	0	0	0
			2015	2016	2017	2018	2019	2020	2021	2022	2023						
	Individual housing, partly slatted floor	Slurry	81.3	81.7	82.2	83.2	83.6	83.9	84.2	83.5	82.9						
	Individual housing, fully slatted floor	Slurry	18.7	18.3	17.8	16.8	16.4	16.1	15.8	16.5	17.1						
	Group-housing, solid floor	Urine and solid	0	0	0	0	0	0	0	0	0						
	Group-housing, partly slatted floor	Slurry and solid	0	0	0	0	0	0	0	0	0						
Sows, Organic production			1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Gestation Period	Partly slatted floor and outdoor yard	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Deep litter and outdoor yard	Deep litter and slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Free-range		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Partly slatted floor and outdoor yard	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Deep litter and outdoor yard	Deep litter and slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Free-range		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2015	2016	2017	2018	2019	2020	2021	2022	2023						
	Partly slatted floor and outdoor yard	Slurry	0	0	0	0	0.0	1.7	1.7	2.0	1.2						
	Deep litter and outdoor yard	Deep litter and slurry	0	0	0	0	13.3	36.5	37.4	38.0	37.3						
	Free-range		0	0	0	0	86.7	61.8	60.9	60.0	61.5						

F) *Continued…*

Sows:

Sows, Organic production	Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Free-range		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Free-range		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2015	2016	2017	2018	2019	2020	2021	2022	2023						
	Free-range		0	0	0	0	1.0	1.0	1.0	1.0	1.0						
Sows, outdoor			1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Outdoor sows (percent of all sows and periods)		0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	1.0	1.3	1.7	2.0	2.3	2.7	3.0
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Outdoor sows (percent of all sows and periods)		3.0	2.6	2.0	2.0	2.0	2.0	2.0	1.7	1.4	1.2	1.2	0.5	1.1	1.1	0.6
			2015	2016	2017	2018	2019	2020	2021	2022	2023						
	Outdoor sows (percent of all sows and periods)		0.5	0.6	0.7	0.8	0.8	0.3	0.3	0.3	0.3						

Weaners:

Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fully slatted floor	Slurry	40.0	42.9	45.7	48.6	51.4	54.3	57.1	60.0	57.1	54.3	51.4	48.6	45.7	42.9	40.0
Partly slatted floor	Slurry	0	0	0	0	0	0	0	0	0.7	1.4	2.2	2.8	3.6	4.3	5.0
Solid floor	Urine and solid	35.0	32.1	29.3	26.4	23.6	20.7	17.9	15.0	13.6	12.1	10.7	9.3	7.8	6.4	5.0
Deep litter	Deep litter	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Two-climate housings, partly slatted floor	Slurry	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	23.6	27.2	30.7	34.3	37.9	41.4	45.0
Partly slatted and drained floor	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Fully slatted floor	Slurry	38.0	36.0	35.0	33.0	31.0	29.1	27.3	25.4	23.0	22.0	22.0	20.2	18.7	16.5	14.8
Partly slatted floor	Slurry	5.0	5.0	5.0	5.0	5.0	0	0	0	0	0	0	0	0	0	0
Solid floor	Urine and solid	5.0	5.0	5.0	5.0	5.0	3.7	2.5	1.2	0.9	0.6	0.6	0.5	0.4	0.4	0.3
Deep litter	Deep litter	5.0	5.0	5.0	5.0	5.0	4.4	3.7	3.1	2.4	1.8	1.8	1.3	1.2	1.3	1.7
Two-climate housings, partly slatted floor	Slurry	47.0	49.0	50.0	52.0	54.0	57.1	60.2	63.3	66.6	67.8	67.8	69.8	71.6	74.4	74.3
Partly slatted and drained floor	Slurry	0	0	0	0	0	5.7	6.3	7.0	7.1	7.8	7.8	8.2	8.1	7.4	8.9

F) *Continued…*

Weaners:

Barn type	Manure types	2015	2016	2017	2018	2019	2020	2021	2022	2023
Fully slatted floor	Slurry	13.4	0	0	0	0	0	0	0	0
Partly slatted floor	Slurry	0	0	0	0	0	0	0	0	0
Solid floor	Urine and so-lid	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Deep litter	Deep litter	1.3	1.1	1.0	2.0	1.9	1.5	0.6	0.5	0.5
Two-climate housings, partly slatted floor	Slurry	75.4	76.9	78.8	78.6	79.3	80.4	81.3	81.2	81.7
Partly slatted and drained floor	Slurry	9.7	21.8	20.0	19.2	18.7	18.0	18.0	18.2	17.7

Weaners, Organic production		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Partly slatted floor and outdoor yard	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep litter and outdoor yard	Deep litter and slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Free-range		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Partly slatted floor and outdoor yard	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep litter and outdoor yard	Deep litter and slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Free-range		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2015	2016	2017	2018	2019	2020	2021	2022	2023						
Partly slatted floor and outdoor yard	Slurry	0	0	0	0	0	5.3	5.7	13.6	10.2						
Deep litter and outdoor yard	Deep litter and slurry	0	0	0	0	63.0	51.3	49.8	44.0	41.4						
Free-range		0	0	0	0	37.0	43.4	44.5	42.4	48.4						

Fattening pigs:

Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fully slatted floor	Slurry	29.0	33.4	37.9	42.3	46.7	51.1	55.6	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Partly slatted floor	Slurry	30.0	28.6	27.1	25.7	24.3	22.9	21.4	20.0	21.3	22.6	23.9	25.1	26.4	27.7	29.0
Partly slatted floor (50-75 % solid floor)	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partly slatted floor (25-49 % solid floor)	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid floor	Urine and solid	40.0	36.4	32.9	29.3	25.7	22.1	18.6	15.0	13.6	12.1	10.7	9.3	7.9	6.4	5.0
Deep litter	Deep litter	1.0	1.6	2.1	2.7	3.3	3.9	4.4	5.0	4.4	3.9	3.3	2.7	2.1	1.6	1.0
Partly slatted floor and partly deep litter	Slurry	0	0	0	0	0	0	0	0	0.7	1.4	2.1	2.9	3.6	4.3	5.0
Partly slatted and drained floor	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

F) *Continued…*

Fattening pigs:

Barn type	Manure types	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Fully slatted floor	Slurry	58.0	57.0	56.0	55.0	53.0	53.0	53.0	53.0	52.9	53.8	53.8	53.2	51.5	46.4	43.7
Partly slatted floor	Slurry	31.0	33.0	34.0	35.0	38.0	0	0	0	0	0	0	0	0	0	0
Partly slatted floor (50-75 % solid floor)	Slurry	0	0	0	0	0	6.2	6.0	5.9	7.0	7.6	7.6	7.5	7.9	8.0	8.6
Partly slatted floor (25-49 % solid floor)	Slurry	0	0	0	0	0	29.1	28.4	27.8	27.7	27.3	27.3	27.6	27.8	29.6	30.2
Solid floor	Urine and solid	5.0	4.0	4.0	4.0	3.0	3.2	3.5	3.7	2.6	1.7	1.7	1.2	1.0	1.0	0.8
Deep litter	Deep litter	1.0	1.0	1.0	1.0	1.0	2.0	3.1	4.1	3.2	2.3	2.3	1.8	1.5	1.4	1.3
Partly slatted floor and partly deep litter	Slurry	5.0	5.0	5.0	5.0	5.0	3.5	2.1	0.6	0.5	0.5	0.5	0.5	0.5	0.7	0.6
Partly slatted and drained floor	Slurry	0	0	0	0	0	3.0	3.9	4.9	6.1	6.8	6.8	8.2	9.8	12.9	14.8
		2015	2016	2017	2018	2019	2020	2021	2022	2023						
Fully slatted floor	Slurry	39.8	0	0	0	0	0	0	0	0						
Partly slatted floor	Slurry	0	0	0	0	0	0	0	0	0						
Partly slatted floor (50-75 % solid floor)	Slurry	8.8	9.3	10.1	10.6	10.6	10.7	10.5	11.3	10.5						
Partly slatted floor (25-49 % solid floor)	Slurry	30.5	31.6	38.3	38.3	38.3	39.0	38.4	37.8	38.1						
Solid floor	Urine and solid	0.6	0.6	0.5	0.4	0.4	0.4	0.4	0.2	0.2						
Deep litter	Deep litter	1.0	0.9	0.8	0.8	0.7	0.5	0.6	0.6	0.5						
Partly slatted floor and partly deep litter	Slurry	0.6	0.5	0.6	0.7	0.9	0.5	0.5	0.4	0.4						
Partly slatted and drained floor	Slurry	18.7	57.1	49.7	49.2	49.1	48.9	49.6	49.7	50.3						
Fattening pigs, Organic production		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Partly slatted floor and outdoor yard	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep litter and outdoor yard	Deep litter and slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Free-range		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Partly slatted floor and outdoor yard	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep litter and outdoor yard	Deep litter and slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Free-range		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2015	2016	2017	2018	2019	2020	2021	2022	2023						
Partly slatted floor and outdoor yard	Slurry	0	0	0	0	93.4	42.2	36.8	33.2	28.9						
Deep litter and outdoor yard	Deep litter and slurry	0	0	0	0	0.0	51.6	57.1	60.5	65.9						
Free-range		0	0	0	0	6.6	6.2	6.1	6.3	5.2						

F) *Continued…*

Poultry:

Livestock categories	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Free range hens	Deep litter and solid	0	0	0	0	0	0	0	1.7	1.7	1.7	5.4	9.0	8.5	8.5	8.7
Organic hens	Deep litter and solid	0	0	0	0	0	0	0	0	0	0.6	2.7	5.5	6.4	9.5	12.4
Barn hens	Deep litter and solid	2.2	4.2	8.6	7.4	6.4	5.4	7.6	8.5	8.6	10.7	15.4	15.4	16.4	14.2	16.6
Battery hens, manure shed	Deep litter and solid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Battery hens, manure tank	Deep litter and solid	97.8	95.8	91.4	92.6	93.6	94.6	92.4	89.8	89.7	87.0	76.5	69.0	68.2	67.0	62.1
Battery hens, manure cellar	Deep litter and solid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aviary	Deep litter and solid	0	0	0	0	0	0	0	0	0	0	0	1.1	0.5	0.7	0.2
Hens for production of brood egg	Deep litter and solid	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Pullet, consumption, net	Solid	22.3	21.2	20.2	19.1	18.0	17.0	15.9	14.8	13.8	12.7	11.7	10.6	9.5	8.5	7.4
Pullet, consumption, floor	Deep litter	52.1	53.2	54.2	55.3	56.4	57.4	58.5	59.6	60.6	61.7	62.7	63.8	64.9	65.9	67.0
Pullet, brood egg, floor	Deep litter	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6
Broilers, (conv. 30 days)	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 32 days)	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 35 days)	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 40 days)	Deep litter	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99.7
Broilers, (conv. 45 days)	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 40 days), slow growth	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 45 days), slow growth	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 50 days), slow growth	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, barn (56 days)	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic broilers (81 days)	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turkey, male	Deep litter	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Turkey, female	Deep litter	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Ducks	Deep litter	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Geese	Deep litter	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

F) *Continued…*
Poultry:

Livestock categories	Manure types	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Free range hens	Deep litter and solid	9.0	9.0	8.3	9.1	7.5	7.9	5.9	5.9	5.8	6.6	6.7	7.6	6.8	4.9	4.9
Organic hens	Deep litter and solid	12.6	13.2	13.5	14.3	13.1	14.0	13.7	15.4	15.7	14.6	14.9	15.7	18.6	18.0	19.7
Barn hens	Deep litter and solid	17.1	16.4	18.1	20.2	22.8	25.3	23.5	20.4	19.0	18.8	16.7	17.2	18.6	21.3	21.3
Battery hens, manure shed	Deep litter and solid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Battery hens, manure tank	Deep litter and solid	61.3	61.2	59.9	56.4	56.6	52.8	56.9	40.2	39.9	34.0	34.9	37.6	36.7	34.3	40.9
Battery hens, manure cellar	Deep litter and solid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aviary	Deep litter and solid	0.0	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0
Hens for production of brood egg	Deep litter and solid	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Pullet, consumption, net	Solid	7.6	7.5	6.0	7.0	5.0	5.7	6.4	7.1	6.7	7.1	7.1	19.3	31.6	17.2	22.0
Pullet, consumption, floor	Deep litter	69.0	67.5	69.0	68.0	69.0	70.3	71.7	73.0	84.1	78.1	78.1	75.5	63.5	39.1	42.1
Pullet, brood egg, floor	Deep litter	23.4	25.0	25.0	25.0	26.0	24.0	21.9	19.9	9.2	14.8	14.8	5.2	4.9	43.7	35.9
Broilers, (conv. 30 days)	Deep litter	0	0	0	0	0	0.1	0.3	0.8	0.2	0.4	0.1	0.1	0.5	0.3	1.1
Broilers, (conv. 32 days)	Deep litter	0	0	0	0	0	3.7	4.8	0.8	2.2	7.0	3.2	10.6	13.6	17.1	22.7
Broilers, (conv. 35 days)	Deep litter	0	0	0	0	0	45.4	40.7	45.1	49.0	56.7	75.6	85.7	80.6	78.5	73.2
Broilers, (conv. 40 days)	Deep litter	99.7	99.9	99.9	99.9	99.9	48.9	53.9	52.9	48.5	35.5	20.9	3.3	4.8	3.2	2.3
Broilers, (conv. 45 days)	Deep litter	0	0	0	0	0	1.8	0.2	0.3	0.0	0.3	0.1	0	0	0.1	0
Broilers, (conv. 40 days), slow growth	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 45 days), slow growth	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 50 days), slow growth	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, barn (56 days)	Deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2
Organic broilers (81 days)	Deep litter	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.5	0.7	0.5
Turkey, male	Deep litter	50	50	50	50	50	51.2	54.5	57.9	45.0	28.8	34.5	40.2	76.3	81.8	77.9
Turkey, female	Deep litter	50	50	50	50	50	48.8	45.5	42.1	55.0	71.2	65.5	59.8	23.7	18.2	22.1
Ducks	Deep litter	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Geese	Deep litter	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

F) *Continued…*

Poultry:

Livestock categories	Manure types	2015	2016	2017	2018	2019	2020	2021	2022	2023
Free range hens	Deep litter and solid	6.3	6.1	7.4	8.7	9.5	7.9	6.3	7.9	8.3
Organic hens	Deep litter and solid	23.8	25.8	27.9	31.9	29.7	30.3	31.3	32.9	30.6
Barn hens	Deep litter and solid	20.6	27.3	35.3	37.7	41.9	46.1	50.0	48.7	50.0
Battery hens, manure shed	Deep litter and solid	0	0	0	1.1	0.3	0.2	0.3	0.4	0.7
Battery hens, manure tank	Deep litter and solid	0.5	3.8	4.7	5.0	5.4	3.6	2.5	1.9	1.8
Battery hens, manure cellar	Deep litter and solid	48.7	37.1	24.7	15.7	13.1	12.0	9.6	8.2	8.7
Aviary	Deep litter and solid	0	0	0	0	0	0	0	0	0
Hens for production of brood egg	Deep litter and solid	100	100	100	100	100	100	100	100	100
Pullet, consumption, net	Solid	18.3	20.5	15.8	11.3	6.8	6.7	5.4	5.6	9.1
Pullet, consumption, floor	Deep litter	42.6	50.8	52.7	55.4	61.0	62.6	64.1	64.8	61.8
Pullet, brood egg, floor	Deep litter	39.1	28.7	31.5	33.3	32.2	30.7	30.5	29.6	29.1
Broilers, (conv. 30 days)	Deep litter	0.2	0.4	0.9	1.4	1.2	1.2	1.4	1.6	1.4
Broilers, (conv. 32 days)	Deep litter	25.2	39.2	51.8	56.9	50.5	30.5	39.6	41.0	33.1
Broilers, (conv. 35 days)	Deep litter	72.4	55.8	41.1	34.0	40.0	56.6	46.7	45.3	34.2
Broilers, (conv. 40 days)	Deep litter	1.4	3.7	4.3	4.6	3.7	5.5	3.1	1.3	3.7
Broilers, (conv. 45 days)	Deep litter	0	0	0	0.8	0.4	0.7	1.2	1.0	2.8
Broilers, (conv. 40 days), slow growth	Deep litter	0	0	0	0	0	0	0	0	9.8
Broilers, (conv. 45 days), slow growth	Deep litter	0	0	0	0	0	0	0	0	11.9
Broilers, (conv. 50 days), slow growth	Deep litter	0	0	0	0	0	0	0	0	1.2
Broilers, barn (56 days)	Deep litter	0.2	0.1	0.5	1.2	2.9	3.8	6.4	7.9	0
Organic broilers (81 days)	Deep litter	0.6	0.8	1.4	1.1	1.3	1.7	1.6	1.9	1.9
Turkey, male	Deep litter	76.0	74.7	72.4	73.2	74.3	79.7	68.1	60.3	74.7
Turkey, female	Deep litter	24.0	25.3	27.6	26.8	25.7	20.3	31.9	39.7	25.3
Ducks	Deep litter	100	100	100	100	100	100	100	100	100
Geese	Deep litter	100	100	100	100	100	100	100	100	100

F) *Continued…*

Fur animals:

	Barn type	Manure types	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mink	Slurry system	Slurry	10.0	11.7	13.3	15.0	16.7	18.3	20.0	20.0	21.7	23.3	25.0	26.2	27.5	28.7	30.0
	Solid manure and urine	Urine and solid	90.0	88.3	86.7	85.0	83.3	81.7	80.0	80.0	78.3	76.7	75.0	73.8	72.5	71.3	70.0
Foxes	Slurry system	Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Solid manure and urine	Urine and solid	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Mink	Slurry system	Slurry	42.0	50.0	55.0	60.0	65.0	72.7	80.5	88.2	92.2	94.8	97.3	96.5	97.2	97.9	97.4
	Solid manure and urine	Urine and solid	58.0	50.0	45.0	40.0	35.0	27.3	19.5	11.8	7.8	5.2	2.7	3.5	2.8	2.1	2.6
Foxes	Slurry system	Slurry	2.0	5.0	10.0	15.0	30.0	0	0	0	0	0	0	0	NO	NO	NO
	Solid manure and urine	Urine and solid	98.0	95.0	90.0	85.0	70.0	100	100	100	100	100	100	100	NO	NO	NO

			2015	2016	2017	2018	2019	2020	2021	2022	2023
	Slurry system	Slurry	97.8	98.1	98.0	98.2	98.7	98.5	NO	NO	28.6
	Solid manure and urine	Urine and solid	2.2	1.9	2.0	1.8	1.3	1.5	NO	NO	71.4
	Slurry system	Slurry	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Solid manure and urine	Urine and solid	NO	NO	NO	NO	NO	NO	NO	NO	NO

Horses, sheep, goats, deer, pheasants and ostrich:

Horses, sheep, goats and ostrich are all housed in deep litter barns all years, 1985-2023

Deer and pheasants are on pasture all years, 1985-2023

NO – not occurring

G) Danish barn systems and associated IPCC Manure Management Systems (MMS).

DK barn systems	DK Manure type	IPCC MMS CH_4	IPCC MMS N_2O
Cattle			
Tethered with urine and solid manure	Liquid	Liquid/Slurry	Liquid/Slurry
	Solid	Solid storage	Solid storage
Tethered with slurry	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Loose-holding with beds, solid floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Loose-holding with beds, slatted floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Loose-holding with beds, slatted floor, scrape	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Loose-holding with beds, drained floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Loose-holding with beds, solid floor with tilt	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Deep litter (all)	Deep bedding >1 month	Cattle and Swine deep bedding (> 1 month)	Cattle and Swine deep bedding (No mixing)
Deep litter, long eating space, solid floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Deep bedding >1 month	Cattle and Swine deep bedding (> 1 month)	Cattle and Swine deep bedding (No mixing)
Deep litter, slatted floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Deep bedding >1 month	Cattle and Swine deep bedding (> 1 month)	Cattle and Swine deep bedding (No mixing)
Deep litter, slatted floor, scrape	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Deep bedding >1 month	Cattle and Swine deep bedding (> 1 month)	Cattle and Swine deep bedding (No mixing)
Deep litter, solid floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Deep bedding >1 month	Cattle and Swine deep bedding (> 1 month)	Cattle and Swine deep bedding (No mixing)
Deep litter, solid floor (Calves)	Deep bedding <1 month	Cattle and Swine deep bedding (< 1 month)	Cattle and Swine deep bedding (No mixing)
Deep litter (boxes)	Deep bedding <1 month	Cattle and Swine deep bedding (< 1 month)	Cattle and Swine deep bedding (No mixing)
Slatted floor-boxes	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Biogas	Slurry	Anaerobic digester	Anaerobic digester
Pasture/Range/Paddock*		Pasture/Range/Paddock	Pasture/Range/Paddock

* For the time spend on grass

G) *Continued…*

DK barn systems	DK Manure type	IPCC MMS CH_4	IPCC MMS N_2O
Swine			
Deep litter + solid floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Deep bedding	Cattle and Swine deep bedding (> 1 month/< 1 month)	Cattle and Swine deep bedding (Active mixing)
Deep litter + slatted floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Deep bedding	Cattle and Swine deep bedding (> 1 month/< 1 month)	Cattle and Swine deep bedding (Active mixing)
Deep litter	Deep bedding	Cattle and Swine deep bedding (> 1 month/< 1 month)	Cattle and Swine deep bedding (Active mixing)
Individual housing, partly slatted floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Individual housing, fully slatted floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Individual housing, solid floor	Liquid	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Solid	Solid storage	Solid storage
Loose housing, partly slatted floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Solid	Solid storage	Solid storage
Loose housing, solid floor	Liquid	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Solid	Solid storage	Solid storage
Outdoor sows and organic swine	Pasture	Pasture/Range/Paddock	Pasture/Range/Paddock
Fully slatted floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Partly slatted floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Solid floor	Liquid	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Solid	Solid storage	Solid storage
Partly slatted floor and partly deep litter	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
	Deep bedding	Cattle and Swine deep bedding (> 1 month/< 1 month)	Cattle and Swine deep bedding (Active mixing)
Partly slatted and drained floor	Slurry	Liquid/Slurry	Liquid/Slurry (with/without natural crust cover)
Biogas	Slurry	Anaerobic digester	Anaerobic digester

* For the time spend on grass

G) *Continued…*

DK barn systems	DK Manure type	IPCC MMS CH_4	IPCC MMS N_2O
Poultry			
Housing with or without litter	Poultry manure	Poultry manure with or without litter	Poultry manure with or without litter
Pasture/Range/Paddock*	Pasture	Pasture/Range/Paddock	Pasture/Range/Paddock
Fur-bearing animals			
Housings	Slurry	Liquid/Slurry	Liquid/Slurry (with natural crust cover)
	Solid	Solid storage	Cattle and Swine deep bedding (No mixing)
Sheep, horses and goats			
Housings	Deep bedding	Sheep, horses and goats	Cattle and Swine deep bedding (No mixing)
Pasture/Range/Paddock*	Pasture	Pasture/Range/Paddock	Pasture/Range/Paddock
Ostrich			
Housings	Solid	Solid storage	Cattle and Swine deep bedding (No mixing)
Pasture/Range/Paddock*	Pasture	Pasture/Range/Paddock	Pasture/Range/Paddock
Pheasants and deer			
Pasture/Range/Paddock*	Pasture	Pasture/Range/Paddock	Pasture/Range/Paddock

* For the time spend on grass

H) Number of grazing days corresponding to the proportion of N in manure deposited on the field during grazing, days per year.

		1985-2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Cattle:													
Dairy cattle		55	48	40	33	25	18	18	18	18	19	19	19
Heifer > ½ year*	Feeding days	196	183	170	158	145	132	126	120	114	109	103	97
	Actual days	165	154	143	133	122	111	106	101	96	91	86	81
Suckling cows*	Feeding days	224	224	224	224	224	224	224	224	224	224	224	224
	Actual days	184	184	184	184	184	184	184	184	184	184	184	184
Calves and Bulls		0	0	0	0	0	0	0	0	0	0	0	0
Swine:													
Sows, weaners and fattening pigs		0	0	0	0	0	0	0	0	0	0	0	0
Sows, outdoor	Only farrow period	365	365	365	365	365	365	365	365	365	365	365	365
Organic sows		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Poultry:													
Pullets, Broilers, Turkeys and Ducks		0	0	0	0	0	0	0	0	0	0	0	0
Hens and organic broilers	Share of manure set outside	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Ostrich	Share of manure set outside	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Geese and Pheasant		365	365	365	365	365	365	365	365	365	365	365	365
Other:													
Sheep and goats (meat and milk)*	Feeding days	265	265	265	265	265	265	265	265	265	265	265	265
	Actual days	215	215	215	215	215	215	215	215	215	215	215	215
Mohair goat*	Feeding days	265	265	265	265	265	265	265	265	265	265	265	265
	Actual days	203	203	203	203	203	203	203	203	203	203	203	203
Horses		182,5	182,5	182,5	182,5	182,5	182,5	182,5	182,5	182,5	182,5	182,5	182,5
Deer		365	365	365	365	365	365	365	365	365	365	365	365
Fur animals		0	0	0	0	0	0	0	0	0	0	0	0

* Actual days on grass are the number of days the heifer is out of the barn. Feeding days on grass is higher than actual days on grass due to a higher feed intake during grazing compared to the period in barn. Feeding days on grass is a conversion of this higher feed intake to days on grass

NO – not occurring

H) *Continued…*

		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Cattle:											
Dairy cattle		19	19	19	20	20	20	20	20	20	20
Heifer > ½ year*	Feeding days	91	85	79	74	68	62	56	56	56	56
	Actual days	77	72	67	62	57	52	47	47	47	47
Suckling cows*	Feeding days	224	224	224	224	224	224	224	224	224	224
	Actual days	184	184	184	184	184	184	184	184	184	184
Calves and Bulls		0	0	0	0	0	0	0	0	0	0
Swine:											
Sows, weaners and fattening pigs		0	0	0	0	0	0	0	0	0	0
Sows, outdoor	Only farrow period	365	365	365	365	365	365	365	365	365	365
Organic sows		NO	NO	NO	NO	NO	195	195	195	195	195
Poultry:											
Pullets, Broilers, Turkeys and Ducks		0	0	0	0	0	0	0	0	0	0
Hens and organic broilers	Share of manure set outside	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Ostrich	Share of manure set outside	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Geese and Pheasant		365	365	365	365	365	365	365	365	365	365
Other:											
Sheep and goats (meat and milk)*	Feeding days	265	265	265	265	265	265	265	265	265	265
	Actual days	215	215	215	215	215	215	215	215	215	215
Mohair goat*	Feeding days	265	265	265	265	265	265	265	265	265	265
	Actual days	203	203	203	203	203	203	203	203	203	203
Horses		182,5	182,5	182,5	182,5	182,5	182,5	182,5	182,5	182,5	182,5
Deer		365	365	365	365	365	365	365	365	365	365
Fur animals		0	0	0	0	0	0	0	0	0	0

* Actual days on grass are the number of days the heifer is out of the barn. Feeding days on grass is higher than actual days on grass due to a higher feed intake during grazing compared to the period in barn. Feeding days on grass is a conversion of this higher feed intake to days on grass.

NO – not occurring

I) Nitrogen excretion and ammonia emission according to livestock category 1985 – 2023.

1) Nitrogen excretion distributed on livestock groups, tonnes N.

N excretion	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Cattle	168 620	164 096	156 160	151 686	150 494	150 382	148 756	144 991	143 739	138 358	137 841	137 000	131 577	129 740	124 454	123 640	123 674
Swine	116 357	119 786	116 856	115 656	112 663	112 566	113 357	117 109	121 188	114 329	107 794	107 811	110 969	117 491	115 950	114 646	120 501
Poultry	7 427	7 758	8 054	9 055	10 178	10 315	10 322	10 942	11 711	13 037	12 263	12 019	11 946	11 793	12 226	12 167	12 343
Horses	6 309	6 264	6 219	6 174	6 129	5 960	5 901	5 839	5 775	5 707	5 637	5 696	5 756	5 815	5 874	5 934	6 131
Sheep	658	868	984	1 209	1 379	1 525	1 767	1 699	1 464	1 327	1 339	1 560	1 592	1 674	1 754	1 852	1 968
Goats	131	129	128	126	124	123	121	119	118	116	114	113	111	127	132	138	155
Fur animals	10 071	11 397	12 268	14 481	15 066	11 089	10 189	10 952	7 295	8 588	8 608	8 935	10 294	10 893	9 676	10 169	10 639
Deer	144	152	160	160	160	160	160	160	160	160	160	160	160	160	160	160	170
N excretion total	309 718	310 450	300 829	298 547	296 194	292 119	290 574	291 812	291 451	281 623	273 756	273 294	272 404	277 693	270 226	268 706	275 580

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cattle	121 427	119 046	115 876	116 110	116 299	120 384	122 619	121 284	121 796	121 905	124 553	125 330	124 270	123 163	126 394	127 694	129 846
Swine	126 552	123 609	128 809	124 799	113 960	117 989	109 910	104 496	103 350	102 921	98 638	96 548	98 347	97 742	95 358	96 327	98 212
Poultry	12 309	12 502	13 258	12 980	11 480	11 299	11 576	10 847	11 221	10 798	10 473	9 866	9 566	9 828	10 399	10 063	10 502
Horses	6 329	6 527	6 725	6 923	7 121	7 319	7 516	7 022	6 527	6 132	6 132	5 934	5 934	6 132	6 429	6 725	6 923
Sheep	1 949	2 008	2 060	2 095	2 119	2 054	1 949	1 916	1 842	1 552	1 499	1 467	1 459	1 395	1 376	1 356	1 360
Goats	151	164	176	181	194	205	231	258	263	206	217	218	201	189	189	188	174
Fur animals	11 172	10 886	12 585	13 718	14 026	14 698	14 860	15 005	15 696	15 566	16 037	16 710	16 912	17 996	17 487	18 722	17 181
Deer	158	155	155	154	154	155	153	152	152	129	115	125	118	122	117	113	123
N excretion total	280 048	274 897	279 645	276 959	265 353	274 103	268 816	260 980	260 848	259 209	257 663	256 198	256 806	256 567	257 748	261 190	264 320

	2019	2020	2021	2022	2023
Cattle	128 109	128 211	127 650	124 912	121 524
Swine	92 931	96 053	93 164	85 281	71 657
Poultry	10 629	10 771	10 369	9 888	10 368
Horses	6 923	7 995	8 002	8 017	7 886
Sheep	1 457	1 328	1 300	1 262	1 237
Goats	196	174	172	173	176
Fur animals	13 479	12 119	NO	NO	34
Deer	124	108	106	101	87
N excretion total	253 847	256 758	240 763	229 633	212 969

NO – not occurring

I) *Continued…*

2) Ammonia emission from animal manure in barn and storage distributed on livestock groups, tonnes NH_3-N.

Ammonia emission	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Cattle	10 580	10 375	9 932	9 691	9 666	9 737	9 696	9 537	9 476	9 175	9 198	9 197	9 067	9 166	8 894	9 589	9 813
Swine	25 829	26 339	25 450	24 953	24 061	23 814	23 740	24 266	24 888	23 239	21 681	21 445	21 825	22 877	22 370	20 845	21 734
Poultry	2 011	2 090	2 225	2 502	2 827	2 837	2 904	3 124	3 325	3 656	3 572	3 491	3 527	3 492	3 644	3 678	3 730
Horses	628	623	619	614	610	593	588	582	576	570	563	569	575	581	596	597	617
Sheep	36	47	54	66	75	83	97	93	80	72	73	85	87	91	96	101	107
Goats	7	7	7	7	7	7	7	7	6	6	6	6	6	7	7	8	8
Fur animals	3 891	4 404	4 739	5 589	5 812	4 277	3 928	4 220	2 810	3 307	3 314	3 439	3 960	4 189	3 720	3 880	4 046
Deer[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emission total	42 982	43 886	43 027	43 425	43 063	41 354	40 966	41 836	41 170	40 035	38 418	38 244	39 060	40 417	39 342	38 712	40 072

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cattle	9 804	10 065	10 188	8 765	9 018	8 914	9 230	9 150	9 164	9 468	9 621	9 675	9 502	9 463	9 844	9 359	9 643
Swine	22 133	21 210	21 887	20 514	18 647	17 011	15 785	14 790	14 503	14 306	13 599	13 200	13 364	13 072	12 109	12 104	12 311
Poultry	3 713	3 773	3 958	3 897	3 401	3 001	3 078	2 878	2 971	2 868	2 700	2 093	1 980	1 906	2 044	1 961	2 049
Horses	637	657	677	697	717	662	679	635	590	554	554	536	536	554	581	608	626
Sheep	106	110	113	114	116	101	96	94	91	76	74	72	72	69	68	67	67
Goats	8	9	10	10	11	10	11	13	13	10	11	11	10	9	9	9	9
Fur animals	4 243	4 122	4 729	5 151	5 246	5 176	5 293	5 397	5 679	5 602	5 764	4 693	4 844	5 098	4 937	5 249	4 798
Deer[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emission total	40 661	39 964	41 581	39 169	37 176	34 897	34 197	32 980	33 036	32 911	32 349	30 309	30 338	30 201	29 623	29 389	29 536

	2019	2020	2021	2022	2023
Cattle	9 548	9 533	9 235	9 098	8 830
Swine	11 603	11 969	11 467	10 411	8 700
Poultry	2 108	2 116	2 027	1 935	1 976
Horses	626	722	722	724	712
Sheep	72	65	64	62	61
Goats	10	9	8	9	9
Fur animals	3 747	3 375	NO	NO	15
Deer[a]	0	0	0	0	0
Emission total	27 747	27 824	23 560	22 275	20 340

[a] All N are deposited on grass

NO – not occurring

I) *Continued…*

3) Ammonia emission from manure distributed on the different parts of the production, tonnes NH_3-N.

Ammonia emission	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Barn	29 227	30 129	29 814	30 444	30 372	28 956	28 736	29 558	28 841	28 237	27 088	27 059	27 825	28 927	28 034	28 399	29 547
Storage	13 755	13 756	13 212	12 978	12 687	12 393	12 224	12 271	12 321	11 789	11 320	11 174	11 223	11 476	11 294	10 298	10 508
Application	48 843	48 095	45 752	44 405	43 428	43 386	41 238	39 259	37 420	34 347	31 784	30 091	28 765	28 103	26 549	25 130	22 011
Pasture	3 727	3 633	3 492	3 441	3 423	3 436	3 442	3 394	3 400	3 285	3 288	3 319	3 260	3 259	3 211	3 216	3 278
Emission total	95 552	95 614	92 270	91 268	89 910	88 171	85 640	84 483	81 982	77 658	73 480	71 643	71 073	71 765	69 088	67 043	65 345

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Barn	30 710	30 595	32 072	32 054	30 456	30 297	29 750	28 718	28 757	28 689	28 179	26 052	25 989	25 922	25 297	24 959	25 011
Storage	9 934	9 351	9 489	7 094	6 699	4 577	4 424	4 239	4 253	4 195	4 143	4 229	4 320	4 249	4 294	4 398	4 491
Application	20 516	18 699	16 763	17 147	16 676	17 650	17 288	16 932	17 270	13 993	13 972	14 304	14 603	14 812	14 923	15 158	15 416
Pasture	3 184	2 950	2 735	2 605	2 476	2 404	2 389	2 223	2 119	2 038	2 037	1 998	1 943	1 879	1 886	1 885	1 878
Emission total	64 344	61 595	61 060	58 900	56 307	54 929	53 850	52 111	52 401	48 916	48 332	46 583	46 854	46 861	46 400	46 400	46 796

	2019	2020	2021	2022	2023
Barn	23 366	23 404	19 542	18 431	16 666
Storage	4 347	4 384	3 982	3 807	3 636
Application	14 949	15 231	14 449	13 772	12 964
Pasture	1 827	1 965	1 939	1 929	1 864
Emission total	44 489	44 985	39 912	37 939	35 129

J) N ex animal, kg N per animal.

A) Cattle, large breed		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Dairy cows	Total N	125.0	127.3	129.5	131.8	134.0	133.0	132.0	131.0	130.0	129.0	128.0	127.8	127.7	127.5	127.3	128.0	128.0
Bulls[a]	Total N	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3
Heifers[b]	Total N	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dairy cows	Total N	130.0	132.8	134.5	136.3	137.4	140.2	140.6	140.9	141.4	141.4	140.9	141.8	146.4	146.6	150.7	155.5	158.8
Bulls[a]	Total N	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	23.5	23.5	23.5	23.5
Heifers[b]	Total N	39.2	39.2	39.2	43.7	48.1	52.6	52.6	52.6	50.0	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4

		2019	2020	2021	2022	2023
Dairy cows	Total N	160.5	160.7	161.0	160.8	159.8
Bulls[a]	Total N	23.5	23.5	23.5	20.2	19.7
Heifers[b]	Total N	50.4	50.4	50.4	50.4	50.4

[a] 6 month to slaughter. Kg N per produced animal

[b] 6 month to calving

J) *Continued…*

B) Swine		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Sows	Total N	31.9	31.2	30.6	29.9	29.3	28.7	28.1	27.5	26.9	26.3	25.7	26.0	26.2	26.5	26.6	26.6	27.2
Fattening pigs[c]	Total N	5.1	5.0	4.9	4.9	4.8	4.5	4.3	4.0	3.8	3.5	3.3	3.3	3.2	3.2	3.2	3.1	3.1
Weaners[c]	Total N	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sows (incl. piglets)	Total N	27.2	27.2	27.2	26.5	26.0	26.4	25.8	26.0	25.1	25.1	25.6	25.2	24.8	24.2	23.9	24.1	23.8
Fattening pigs[c]	Total N	3.3	3.2	3.2	3.2	3.0	3.1	3.0	2.9	2.8	2.8	2.8	2.9	2.9	2.9	2.9	3.0	3.0
Weaners[c]	Total N	0.7	0.6	0.6	0.7	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

		2019	2020	2021	2022	2023
Sows (incl. piglets)	Total N	24.2	23.8	23.5	23.2	23.0
Fattening pigs[c]	Total N	2.9	2.9	2.7	2.6	2.6
Weaners[c]	Total N	0.5	0.5	0.4	0.4	0.4

[c] per. produced animal

J) N ex animal, kg N per animal.

Continued…

C) Poultry		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Battery hens[d]	Total N	72.2	72.2	72.2	72.2	72.2	74.4	76.6	78.8	81.0	83.2	85.4	85.4	85.4	85.4	85.4	84.9	84.9
Broilers[e]	Total N	48.4	48.4	48.4	48.4	48.4	49.8	51.3	52.8	54.3	55.7	57.2	57.2	57.2	57.2	57.2	56.9	56.9
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Battery hens[d]	Total N	85.7	85.0	84.1	91.2	91.2	86.4	86.8	86.8	86.8	81.8	81.1	79.5	83.1	77.7	77.7	77.7	77.7
Broilers[e]	Total N	57.4	56.9	56.3	61.1	61.1	57.9	58.2	58.2	58.2	54.8	54.4	53.3	55.7	52.1	52.1	52.1	52.1
		2019	2020	2021	2022	2023												
Battery hens[d]	Total N	77.7	77.0	77.0	75.2	73.8												
Broilers[e]	Total N	62.9	58.9	58.6	58.0	58.6												

[d] pr. 100 animal

[e] pr. 1000 produced animal

J) *Continued…*

D) Fur animals		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Mink (incl. cubs)	Total N	5.2	5.1	5.0	5.0	4.9	4.8	4.8	4.7	4.7	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Mink (incl. cubs)	Total N	4.6	4.6	5.1	5.4	5.2	5.2	5.3	5.5	5.8	5.6	5.4	5.3	5.1	5.3	5.4	5.5	5.1
		2019	2020	2021	2022	2023												
Mink (incl. cubs)	Total N	5.5	5.5	5.5	5.5	5.5												

Sources: Laursen (1994), Poulsen & Kristensen (1997), Kyllingsbæk et al. (2000), Poulsen et al. (2001), Børsting & Hellwing (2024)

K) TAN ex animal.

kg per animal		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Cattle																		
Dairy cows	TAN	66.7	67.0	65.7	65.7	67.2	65.8	65.7	66.3	66.1	68.6	70.5	72.6	72.6	71.7	68.2	68.3	66.9
Bulls[a]	TAN	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	15.6	15.6	15.6	15.6	15.6	15.6	15.6	14.0	13.8
Heifers[b]	TAN	35.9	35.9	35.9	33.5	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9
Swine																		
Sows	TAN	19.8	19.2	19.3	18.7	18.7	19.0	18.7	18.4	17.9	17.7	17.8	17.5	17.8	17.5	17.3	17.0	16.8
Fattening pigs[c]	TAN	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	2.0	2.0	1.9	1.9	1.7	1.7	1.6
Weaners[c]	TAN	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2
Fur animals																		
Mink	TAN	3.9	3.9	4.1	4.3	4.2	4.1	3.9	3.7	3.9	3.9	4.0	3.7	4.0	4.0	4.0	4.0	4.0

[a] 6 month to slaughter. Per produced animal

[b] 6 month to calving

[c] per produced animal

Source: Børsting & Hellwing (2024)

L) Ammonia emission factors for barn units.

Sows			Urine TAN	Slurry TAN	Solid manure Total N	Deep litter Total N
	Barn type		% NH_3-N loss of TAN ex animal		% NH_3-N loss of N ex animal	
	Individual, mating and gestation	Partly slatted floor	-	13	-	-
		Full slatted floor	-	19	-	-
		Solid floor	21	-	16	-
	Group, mating and gestation	Deep litter	-	-	-	15
		Deep litter + slatted floor	-	16	-	15
		Deep litter + solid floor	-	19	-	15
		Partly slatted floor	-	16	-	-
	Farrowing crate	Full slatted floor	-	26	-	-
		Partly slatted floor	-	13	-	-
	Farrowing pen	Solid floor	15	-	20	-
		Partly slatted floor	-	22	-	15
Organic production	Gestation period	Partly slatted floor and outdoor yard	-	16	-	-
		Deep litter and outdoor yard	-	16	-	15

L) *Continued…*

		Urine TAN	Slurry TAN	Solid manure Total N	Deep litter Total N
	Floor or manure type	% NH_3-N loss of TAN ex animal		% NH_3-N loss of N ex animal	
Weaners	Full slatted floor	-	24	-	-
	Partly slatted and drained floor	-	21	-	-
	Two-climate housing, partly slatted floor	-	10	-	-
	Solid floor	37	-	25	-
	Deep litter	-	-	-	15
Organic production	Partly slatted floor and outdoor yard	-	24	-	-
	Deep litter and outdoor yard	-	15	-	15
Fattening pigs	Partly slatted floor (50-75 % solid)	-	13	-	-
	Partly slatted floor (25-49% solid)	-	17	-	-
	Partly slatted and drained floor	-	21	-	-
	Full slatted floor	-	24	-	-
	Solid floor	27	-	-	18
	Partly slatted floor and partly deep litter	-	18	-	15
	Deep litter	-	-	-	15
Organic production	Partly slatted floor and outdoor yard	-	38	-	-
	Deep litter and outdoor yard	-	34	-	15

L) *Continued…*

Poultry			Solid manure Total N	Deep litter Total N	Slurry Total N
	Barn type	Floor or manure type	% NH_3-N loss of N ex animal		
Hens and pullets	Free-range, organic and barn	Deep pit	40	25	-
		Deep litter	-	28	-
		Floor on floor system, manure belt	10	25	10
	Battery	Deep pit	12	-	-
		Manure belt	10	-	10
Broilers	Conventional	Deep litter	-	10	-
	Organic and barn	Deep litter	-	13	-
Turkeys, ducks and geese		Deep litter	-	20	-

L) *Continued…*

Other			Urine TAN	Slurry TAN	Solid manure Total N	Deep litter Total N
	Barn type	Floor or manure type	% NH_3-N loss of TAN ex animal		% NH_3-N loss of N ex animal	
Mink	Manure channel	Slurry system	-	67	-	-
	Manure channel, weekly emptying	Deep litter and slurry	-	30	-	40
Other fur animals		Solid manure and urine	35	-	35	-
Horses, sheep and goats			-	-	-	15

M) Correction for lack of surface crust / fixed cover on slurry tanks.

	Emission factor[1]	1985-1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
	NH_3-N % of total-N	Total N												
Swine														
No cover	9%	40%	40%	40%	40%	40%	40%	20%	20%	10%	5%	5%	5%	5%
Floating cover	2%	60%	60%	59%	59%	58%	58%	77%	76%	86%	90%	90%	89%	88%
Fixed cover	1%	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	5%	6%	7%
Emission during storage		4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	3.4%	3.4%	2.7%	2.3%	2.3%	2.3%	2.3%
Cattle														
No cover	6%	20%	20%	20%	20%	20%	20%	5%	5%	5%	2%	2%	2%	2%
Floating cover	2%	80%	80%	80%	79%	79%	78%	93%	92%	92%	96%	96%	96%	96%
Fixed cover	1%	0%	0%	0%	1%	1%	2%	2%	3%	3%	2%	2%	2%	2%
Emission during storage		2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.2%	2.2%	2.2%	2.1%	2.1%	2.1%	2.1%
Fur animals														
No cover	9%	20%	20%	20%	20%	20%	20%	5%	5%	5%	2%	2%	2%	2%
Floating cover	2%	80%	80%	80%	80%	80%	80%	95%	95%	95%	98%	98%	97%	95%
Fixed cover	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	3%
Emission during storage		3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	2.4%	2.4%	2.4%	2.1%	2.1%	2.1%	2.1%
Biogas treated slurry														
No cover	9%	40%	40%	40%	40%	40%	40%	20%	20%	10%	5%	5%	5%	5%
Floating cover	2%	60%	60%	60%	60%	60%	60%	80%	80%	89%	94%	93%	92%	91%
Fixed cover	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	2%	3%	4%
Emission during storage		3.4%	10.8%	10.8%	10.8%	10.8%	10.8%	10.8%	7.4%	7.4%	5.7%	4.8%	4.8%	4.8%

[1] Poulsen et al., 2001

M) *Continued…*

	Emissions factor[2]	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	NH3-N % of TAN									TAN								
Swine																		
No cover	11.4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Floating cover	2.5%	87%	86%	85%	85%	84%	83%	82%	81%	79%	76%	74%	71%	71%	71%	71%	71%	71%
Fixed cover	1.3%	8%	9%	10%	10%	11%	12%	13%	14%	17%	19%	22%	24%	24%	24%	24%	24%	24%
Emission under storage		2.9%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%
Total N		*2.3%*	*2.3%*	*2.3%*	*2.3%*	*2.2%*	*2.2%*	*2.2%*	*2.2%*	*2.2%*	*2.2%*	*2.2%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*
Cattle																		
No cover	10.3%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Floating cover	3.4%	95%	95%	95%	95%	95%	94%	94%	94%	93%	91%	90%	88%	88%	88%	88%	88%	88%
Fixed cover	1.7%	3%	3%	3%	3%	3%	4%	4%	4%	6%	7%	9%	10%	10%	10%	10%	10%	10%
Emission under storage		3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%
Total N		*2.1%*	*2.1%*	*2.1%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Fur animals																		
No cover	12.9%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Floating cover	2.9%	94%	92%	91%	89%	88%	86%	85%	83%	80%	76%	73%	69%	69%	69%	69%	69%	69%
Fixed cover	1.4%	5%	6%	8%	9%	11%	12%	14%	15%	19%	22%	26%	29%	29%	29%	29%	29%	29%
Emission under storage		3.0%	3.0%	3.0%	3.0%	2.9%	2.9%	2.9%	2.9%	2.8%	2.8%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%
Total N		*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*1.9%*	*1.9%*	*1.9%*	*1.9%*	*1.9%*	*1.9%*	*1.9%*	*1.9%*
Biogas treated slurry																		
No cover	27.3%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Floating cover	5.2%	89%	88%	87%	86%	85%	83%	82%	81%	78%	75%	72%	69%	69%	69%	69%	69%	69%
Fixed cover	2.6%	6%	7%	8%	9%	10%	12%	13%	14%	17%	20%	23%	26%	26%	26%	26%	26%	26%
Emission under storage		6.2%	6.1%	6.1%	6.1%	6.0%	6.0%	6.0%	5.9%	5.9%	5.8%	5.7%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%
Total N		*4.7%*	*4.7%*	*4.7%*	*4.7%*	*4.6%*	*4.6%*	*4.6%*	*4.6%*	*4.5%*	*4.5%*	*4.4%*	*4.3%*	*4.3%*	*4.3%*	*4.3%*	*4.3%*	*4.3%*

[2] Hansen et al., 2008

N) Correction for lack of cover on manure heaps.

	Emission factor NH$_3$-N in % of N ex barn-total	Solid manure 2007-2023
Cattle		
No cover	5%	50%
Full cover	3%	50%
Emission during storage		**4%**
Swine		
No cover	25%	50%
Full cover	13%	50%
Emission during storage		**19%**
Hens		
No cover	10%	50%
Full cover	5%	50%
Emission during storage		**7.5%**
Broilers		
No cover	15%	50%
Full cover	8%	50%
Emission during storage		**11,5%**
Fur animals		
No cover	15%	50%
Full cover	8%	50%
Emission during storage		**11.5%**
Horses, sheep and goats		
No cover	5%	50%
Full cover	3%	50%
Emission during storage		**4%**

O) Percentage loss of NH_3 from application of slurry (NH_3-N of TAN ex storage) and solid manure (NH_3-N of N ex storage).

Weighted emission factor	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Slurry untreated/acidified during storage and application																				
Cattle[1]	47.74	47.61	47.48	47.35	47.22	46.08	44.26	42.54	40.38	38.60	36.79	35.06	34.14	32.94	31.83	28.21	23.86	21.12	17.23	11.99
Swine	24.44	24.28	24.12	23.96	23.80	25.44	24.14	22.95	21.56	20.37	18.97	17.81	17.34	16.72	16.22	16.15	13.28	11.85	11.45	11.22
Acidified slurry in barns																				
Cattle	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biogas treated slurry	42.62	42.44	42.26	42.08	41.90	42.62	41.02	39.58	37.75	36.30	34.56	33.15	32.55	31.57	30.90	29.80	25.70	23.17	23.16	22.94
Solid manure	10.28	9.86	9.44	9.02	8.60	8.49	8.39	8.28	8.17	8.06	7.96	7.85	7.70	7.55	7.40	7.12	7.07	7.21	7.05	6.97

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Slurry untreated/acidified during storage and application																			
Cattle[1]	11.81	11.81	11.81	11.81	11.81	12.35	9.39	9.66	9.98	10.29	10.53	10.44	10.21	10.21	10.21	10.21	10.21	10.21	10.21
Swine	11.13	11.13	11.13	11.13	11.13	11.18	9.62	9.61	9.59	9.59	9.58	9.61	9.61	9.61	9.61	9.61	9.61	9.61	9.61
Acidified slurry in barns[1]																			
Cattle	NO	NO	11.81	11.81	11.81	12.35	16.32	16.32	16.32	16.32	16.32	16.32	16.32	16.32	16.32	16.32	16.32	16.32	16.32
Swine	NO	NO	11.13	11.13	11.13	11.18	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04
Biogas treated slurry	22.62	22.62	22.62	22.62	22.62	22.76	14.33	14.33	14.33	14.33	14.33	14.33	14.33	14.33	14.33	14.33	14.33	14.33	14.33
Solid manure	7.55	7.55	7.55	7.55	7.55	7.55	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82

[1]2007-2010 no information about application practice for acidified slurry is available, so the same EF as untreated slurry is used

P) Share of manure applied per application practice.

P-a) Slurry untreated/acidified during storage and application - Cattle.

Crop status +/-	Application time	Lying time Hours	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	Injection																		
-	March	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5
-	April	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	3	5
+	March	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	April	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Summer, grass injection	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	3
-	Summer, before winter rape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hose application																		
-	March	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	12	0	0	0	0	0	0	1	2	3	4	6	7	8	9	10	9	10
-	March	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	April	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	May	12	0	0	0	0	0	0	1	1	2	2	3	3	4	4	5	5	5
-	June	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	July	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	March	0	0	0	0	0	0	0	1	1	2	3	3	4	5	5	6	6	7
+	April	0	0	0	0	0	0	0	2	3	3	5	6	8	9	11	12	13	18
+	May	0	0	0	0	0	0	0	1	3	3	5	7	8	10	11	12	13	18
+	Summer	0	0	0	0	0	0	0	1	2	3	3	4	5	5	4	4	4	4
-	Summer	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	12	0	0	0	0	0	0	1	1	2	2	3	3	3	2	2	2	3
-	Summer	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Autumn	0	0	0	0	0	0	0	0	1	2	3	3	4	4	4	4	4	5
-	Autumn	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	12	0	0	0	0	0	0	0	1	1	1	2	2	1	1	0	0	0
-	Autumn	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

-: indicate bare soil. +: indicate growth

P-a) Slurry untreated/acidified during storage and application – Cattle – *Continued…*

Crop status +/-	Application time	Lying time Hours	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	Broad spreading																		
-	Winter-spring	< 12	26	27	28	29	30	26	25	24	23	22	21	20	18	17	15	14	6
-	Winter-spring	> 12	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2
-/+	Winter-spring	0	15	15	15	15	15	20	20	20	20	20	20	20	18	17	15	14	6
+	Spring-summer	0	8	8	8	8	8	8	7	6	5	4	3	2	2	2	2	2	1
+	Late summer-autumn	0	7	7	7	7	7	7	6	5	5	4	3	2	2	1	1	1	1
-	Late summer-autumn	< 12	2	3	3	4	4	4	4	4	4	3	3	3	3	2	2	2	1
-	Late summer-autumn	> 12	8	7	7	6	6	6	5	4	4	3	3	2	2	1	1	1	1
-	Late summer-autumn	0	29	28	27	26	25	24	20	16	12	8	4	0	0	0	0	0	0
		Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

-: indicate bare soil. +: indicate growth

P-a) Slurry untreated/acidified during storage and application – Cattle – *Continued…*

Crop status +/-	Application time	Lying time Hours	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Injection																		
-	March	0	8	11	21	20	20	20	20	20	20	8	8	8	8	8	8	8	8
-	April	0	8	12	21	21	21	21	21	21	21	41	41	41	41	41	41	41	41
+	March	0	0	0	0	1	1	1	1	1	1	9	9	9	9	9	9	9	9
+	April	0	0	0	0	2	2	2	2	2	2	9	9	9	9	9	9	9	9
+	Summer, grass injection	0	4	4	5	5	5	5	5	5	5	19	19	19	19	19	19	19	19
-	Summer, before winter rape	0	0	1	6	6	6	6	6	6	6	1	1	1	1	1	1	1	1
+	Autumn	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2
-	Autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hose application																		
-	March	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	6	10	14	8	8	8	8	8	8	8	0	0	0	0	0	0	0	0
-	March	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	April	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	May	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	June	6	5	4	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0
-	July	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	March	0	7	7	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3
+	April	0	17	15	10	9	9	9	9	9	9	6	6	6	6	6	6	6	6
+	May	0	17	15	10	9	9	9	9	9	9	2	2	2	2	2	2	2	2
+	Summer	0	3	3	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0
-	Summer	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	6	3	5	5	5	5	5	5	5	5	0	0	0	0	0	0	0	0
-	Summer	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Autumn	0	5	5	4	4	4	4	4	4	4	0	0	0	0	0	0	0	0
-	Autumn	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

-: indicate bare soil. +: indicate growth

P-a) Slurry untreated/acidified during storage and application – Cattle – *Continued…*

Crop status +/-	Application time	Lying time Hours	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Broad spreading																		
-	Winter-spring	< 12	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Winter-spring	> 12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-/+	Winter-spring	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Spring-summer	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Late summer-autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	< 12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	> 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

-: indicate bare soil. +: indicate growth

P-a) Slurry untreated/acidified during storage and application – Cattle – *Continued…*

Crop status +/-	Application time	Lying time Hours	2019	2020	2021	2022	2023
	Injection						
-	March	0	8	8	8	8	8
-	April	0	41	41	41	41	41
+	March	0	9	9	9	9	9
+	April	0	9	9	9	9	9
+	Summer, grass injection	0	19	19	19	19	19
-	Summer, before winter rape	0	1	1	1	1	1
+	Autumn	0	2	2	2	2	2
-	Autumn	0	0	0	0	0	0
	Hose application						
-	March	24	0	0	0	0	0
-	March	12	0	0	0	0	0
-	March	6	0	0	0	0	0
-	March	4	0	0	0	0	0
-	April	24	0	0	0	0	0
-	May	12	0	0	0	0	0
-	June	6	0	0	0	0	0
-	July	4	0	0	0	0	0
+	March	0	3	3	3	3	3
+	April	0	6	6	6	6	6
+	May	0	2	2	2	2	2
+	Summer	0	0	0	0	0	0
-	Summer	24	0	0	0	0	0
-	Summer	12	0	0	0	0	0
-	Summer	6	0	0	0	0	0
-	Summer	4	0	0	0	0	0
+	Autumn	0	0	0	0	0	0
-	Autumn	24	0	0	0	0	0
-	Autumn	12	0	0	0	0	0
-	Autumn	6	0	0	0	0	0
-	Autumn	4	0	0	0	0	0

-: indicate bare soil. +: indicate growth

Crop status +/-	Application time	Lying time Hours	2019	2020	2021	2022	2023
	Broad spreading						
-	Winter-spring	< 12	0	0	0	0	0
-	Winter-spring	> 12	0	0	0	0	0
-/+	Winter-spring	0	0	0	0	0	0
+	Spring-summer	0	0	0	0	0	0
+	Late summer-autumn	0	0	0	0	0	0
-	Late summer-autumn	< 12	0	0	0	0	0
-	Late summer-autumn	> 12	0	0	0	0	0
-	Late summer-autumn	0	0	0	0	0	0
		Total	100	100	100	100	100

P-a) Slurry untreated/acidified during storage and application - Swine.

Crop status +/-	Application time	Lying time Hours	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	Injection																		
-	March	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	5
-	April	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	6
+	March	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	April	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Summer, grass injection	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
-	Summer, before winter rape	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2
+	Autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hose application																		
-	March	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	12	0	0	0	0	0	0	1	1	2	3	4	5	6	6	10	7	7
-	March	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	April	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	May	12	0	0	0	0	0	0	1	2	3	3	5	5	6	7	5	7	8
-	June	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	July	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	March	0	0	0	0	0	0	0	1	1	2	3	4	4	5	5	6	6	11
+	April	0	0	0	0	0	0	0	1	3	3	6	6	9	10	12	13	14	16
+	May	0	0	0	0	0	0	0	1	4	4	6	6	9	10	12	13	14	16
+	Summer	0	0	0	0	0	0	0	1	1	2	3	3	4	4	4	4	4	5
-	Summer	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	12	0	0	0	0	0	0	1	1	2	2	3	3	3	2	2	2	3
-	Summer	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	12	0	0	0	0	0	0	1	2	3	3	5	5	4	3	2	2	3
-	Autumn	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

-: indicate bare soil. +: indicate growth

P-a) Slurry untreated/acidified during storage and application – Swine – *Continued…*

Crop status +/-	Application time	Lying time Hours	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	Broad spreading																		
-	Winter-spring	< 12	26	27	28	29	30	26	25	24	23	22	21	20	18	17	15	14	6
-	Winter-spring	> 12	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2
-/+	Winter-spring	0	15	15	15	15	15	20	20	20	20	20	20	20	18	17	15	14	6
+	Spring-summer	0	8	8	8	8	8	8	7	6	5	4	3	2	2	2	2	2	1
+	Late summer-autumn	0	7	7	7	7	7	7	6	5	5	4	3	2	2	1	1	1	1
-	Late summer-autumn	< 12	2	3	3	4	4	4	4	4	4	3	3	3	3	2	2	2	1
-	Late summer-autumn	> 12	8	7	7	6	6	6	5	4	4	3	3	2	2	1	1	1	1
-	Late summer-autumn	0	29	28	27	26	25	24	20	16	12	8	4	0	0	0	0	0	0
		Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

-: indicate bare soil. +: indicate growth

P-a) Slurry untreated/acidified during storage and application – Swine – *Continued…*

Crop status +/-	Application time	Lying time Hours	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Injection																		
-	March	0	8	6	6	7	7	7	7	7	7	8	8	8	8	8	8	8	8
-	April	0	8	7	7	7	7	7	7	7	7	24	24	24	24	24	24	24	24
+	March	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2
+	April	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3
+	Summer, grass injection	0	2	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
-	Summer, before winter rape	0	2	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3	3
+	Autumn	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
-	Autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hose application																		
-	March	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	6	7	9	8	7	7	7	7	7	7	0	0	0	0	0	0	0	0
-	March	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	April	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	May	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	June	6	8	9	8	7	7	7	7	7	7	0	0	0	0	0	0	0	0
-	July	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	March	0	11	13	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
+	April	0	15	20	23	28	28	28	28	28	28	30	30	30	30	30	30	30	30
+	May	0	15	21	23	18	18	18	18	18	18	9	9	9	9	9	9	9	9
+	Summer	0	5	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1
-	Summer	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	6	3	3	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0
-	Summer	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	6	3	3	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0
-	Autumn	4	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3

-: indicate bare soil. +: indicate growth

P-a) Slurry untreated/acidified during storage and application – Swine – *Continued…*

Crop status +/-	Application time	Lying time Hours	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Broad spreading																		
-	Winter-spring	< 12	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Winter-spring	> 12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-/+	Winter-spring	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Spring-summer	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Late summer-autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	< 12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	> 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

-: indicate bare soil. +: indicate growth

P-a) Slurry untreated/acidified during storage and application – Swine – *Continued…*

Crop status +/-	Application time	Lying time Hours	2019	2020	2021	2022	2023
	Injection						
-	March	0	8	8	8	8	8
-	April	0	24	24	24	24	24
+	March	0	2	2	2	2	2
+	April	0	3	3	3	3	3
+	Summer, grass injection	0	2	2	2	2	2
-	Summer, before winter rape	0	3	3	3	3	3
+	Autumn	0	1	1	1	1	1
-	Autumn	0	0	0	0	0	0
	Hose application						
-	March	24	0	0	0	0	0
-	March	12	0	0	0	0	0
-	March	6	0	0	0	0	0
-	March	4	0	0	0	0	0
-	April	24	0	0	0	0	0
-	May	12	0	0	0	0	0
-	June	6	0	0	0	0	0
-	July	4	0	0	0	0	0
+	March	0	14	14	14	14	14
+	April	0	30	30	30	30	30
+	May	0	9	9	9	9	9
+	Summer	0	1	1	1	1	1
-	Summer	24	0	0	0	0	0
-	Summer	12	0	0	0	0	0
-	Summer	6	0	0	0	0	0
-	Summer	4	0	0	0	0	0
+	Autumn	0	0	0	0	0	0
-	Autumn	24	0	0	0	0	0
-	Autumn	12	0	0	0	0	0
-	Autumn	6	0	0	0	0	0
-	Autumn	4	3	3	3	3	3

-: indicate bare soil. +: indicate growth

Crop status +/-	Application time	Lying time Hours	2019	2020	2021	2022	2023
	Broad spreading						
-	Winter-spring	< 12	0	0	0	0	0
-	Winter-spring	> 12	0	0	0	0	0
-/+	Winter-spring	0	0	0	0	0	0
+	Spring-summer	0	0	0	0	0	0
+	Late summer-autumn	0	0	0	0	0	0
-	Late summer-autumn	< 12	0	0	0	0	0
-	Late summer-autumn	> 12	0	0	0	0	0
-	Late summer-autumn	0	0	0	0	0	0
		Total	100	100	100	100	100

P-b) Acidified slurry in barns - Cattle– *Continued…*

Crop status +/-	Application time	Lying time Hours	1985-2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Injection		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Hose application															
-	March	24		0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	12		0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	6		0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	4		0	0	0	0	0	0	0	0	0	0	0	0	0
-	April	24		0	0	0	0	0	0	0	0	0	0	0	0	0
-	May	12		0	0	0	0	0	0	0	0	0	0	0	0	0
-	June	6		0	0	0	0	0	0	0	0	0	0	0	0	0
-	July	4		0	0	0	0	0	0	0	0	0	0	0	0	0
+	March	0		20	20	20	20	20	20	20	20	20	20	20	20	20
+	April	0		20	20	20	20	20	20	20	20	20	20	20	20	20
+	May	0		25	25	25	25	25	25	25	25	25	25	25	25	25
+	Summer	0		30	30	30	30	30	30	30	30	30	30	30	30	30
-	Summer	24		0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	12		0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	6		0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	4		0	0	0	0	0	0	0	0	0	0	0	0	0
+	Autumn	0		5	5	5	5	5	5	5	5	5	5	5	5	5
-	Autumn	24		0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	12		0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	6		0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	4		0	0	0	0	0	0	0	0	0	0	0	0	0
	Broad spreading		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100

-: indicate bare soil. +: indicate growth

1985-2006 not occurring and 2007-2010 no information about application practice for acidified slurry is available

NO – not occurring

P-c) Biogas treated slurry.

Crop status +/-	Application time	Lying time Hours	1985-1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
	Injection																		
-	March	0		0	0	1	1	1	1	1	1	1	2	5	8	6	6	7	7
-	April	0		0	0	0	0	0	0	0	1	1	3	6	8	7	7	7	7
+	March	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	April	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Summer, grass injection	0		0	0	0	0	0	0	0	0	0	0	1	2	1	1	1	1
-	Summer, before winter rape	0		0	0	1	1	1	1	1	2	2	2	2	2	1	1	2	2
+	Autumn	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hose application																		
-	March	24		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	12		1	1	2	3	4	5	6	6	10	7	7	0	0	0	0	0
-	March	6		0	0	0	0	0	0	0	0	0	0	0	7	9	8	7	7
-	March	4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	April	24		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	May	12		1	2	3	3	5	5	6	7	5	7	8	0	0	0	0	0
-	June	6		0	0	0	0	0	0	0	0	0	0	0	8	9	8	7	7
-	July	4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	March	0		1	1	2	3	4	4	5	5	6	6	11	11	13	14	14	14
+	April	0		1	3	3	6	6	9	10	12	13	14	16	15	20	23	28	28
+	May	0		1	4	4	6	6	9	10	12	13	14	16	15	21	23	18	18
+	Summer	0		1	1	2	3	3	4	4	4	4	4	5	5	3	3	3	3
-	Summer	24		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	12		1	1	2	2	3	3	3	2	2	2	3	0	0	0	0	0
-	Summer	6		0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3
-	Summer	4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Autumn	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	24		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	12		1	2	3	3	5	5	4	3	2	2	3	0	0	0	0	0
-	Autumn	6		0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3
-	Autumn	4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

-: indicate bare soil. +: indicate growth

1985-1989 not occurring, 1990 no information about application practice for biogas treated slurry is available

P-c) Biogas treated slurry – *Continued…*

Crop status +/-	Application time	Lying time Hours	1985-1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
	Broad spreading																		
-	Winter-spring	< 12		25	24	23	22	21	20	18	17	15	14	6	5	2	0	0	0
-	Winter-spring	> 12		5	5	5	5	5	5	5	5	5	5	2	1	0	0	0	0
-/+	Winter-spring	0		20	20	20	20	20	20	18	17	15	14	6	4	2	0	0	0
+	Spring-summer	0		7	6	5	4	3	2	2	2	2	2	1	1	0	0	0	0
+	Late summer-autumn	0		6	5	5	4	3	2	2	1	1	1	1	0	0	0	0	0
-	Late summer-autumn	< 12		4	4	4	3	3	3	3	2	2	2	1	2	0	0	0	0
-	Late summer-autumn	> 12		5	4	4	3	3	2	2	1	1	1	1	0	0	0	0	0
-	Late summer-autumn	0		20	16	12	8	4	0	0	0	0	0	0	0	0	0	0	0
		Total		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

-: indicate bare soil. +: indicate growth

1985-1989 not occurring, 1990 no information about application practice for biogas treated slurry is available

P-c) Biogas treated slurry – C*ontinued…* -: indicate bare soil. +: indicate growth. NO – not occurring

Crop status +/-	Application time	Lying time Hours	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Injection																		
-	March	0	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6
-	April	0	7	7	7	7	34	34	34	34	34	34	34	34	34	34	34	34	34
+	March	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6
+	April	0	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7	7
+	Summer, grass injection	0	1	1	1	1	14	14	14	14	14	14	14	14	14	14	14	14	14
-	Summer, before winter rape	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
+	Autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
	Hose application																		
-	March	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	6	7	7	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0
-	March	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	April	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	May	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	June	6	7	7	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0
-	July	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	March	0	14	14	14	14	7	7	7	7	7	7	7	7	7	7	7	7	7
+	April	0	28	28	28	28	18	18	18	18	18	18	18	18	18	18	18	18	18
+	May	0	18	18	18	18	4	4	4	4	4	4	4	4	4	4	4	4	4
+	Summer	0	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1
-	Summer	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	6	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Summer	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	6	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Autumn	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Broad spreading		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

P-d) Solid manure.

Crop status +/-	Application time	Lying time Hours	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	Broad spreading																		
-	Winter-spring	24	19	18	17	16	15	14	14	13	12	11	11	10	10	10	10	9	10
-	Winter-spring	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Winter-spring	6	18	16	14	12	10	11	11	12	13	14	14	15	15	15	15	14	14
-	Winter-spring	4	13	16	19	22	25	26	26	27	28	29	29	30	32	33	35	38	49
+	Winter-spring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Spring-summer	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Spring-summer	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Spring-summer	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Spring-summer	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Spring-summer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Late summer-autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	24	24	23	22	21	20	19	19	18	17	16	16	15	13	12	10	9	6
-	Late summer-autumn	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	6	13	11	9	7	5	5	5	5	5	5	5	5	5	5	5	5	3
-	Late summer-autumn	4	13	16	19	22	25	25	25	25	25	25	25	25	25	25	25	26	18
		Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

-: indicate bare soil. +: indicate growth.

P-d) Solid manure – *Continued…*

Crop status +/-	Application time	Lying time Hours	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Broad spreading																		
-	Winter-spring	24	11	11	11	10	10	10	10	10	10	0	0	0	0	0	0	0	0
-	Winter-spring	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Winter-spring	6	15	15	14	14	14	14	14	14	14	0	0	0	0	0	0	0	0
-	Winter-spring	4	54	54	56	52	52	52	52	52	52	66	66	66	66	66	66	66	66
+	Winter-spring	0	0	0	0	5	5	5	5	5	5	7	7	7	7	7	7	7	7
-	Spring-summer	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Spring-summer	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Spring-summer	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Spring-summer	4	0	0	0	5	5	5	5	5	5	8	8	8	8	8	8	8	8
+	Spring-summer	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7	7	7
+	Late summer-autumn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	24	5	4	4	3	3	3	3	3	3	0	0	0	0	0	0	0	0
-	Late summer-autumn	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	6	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	Late summer-autumn	4	13	15	15	11	11	11	11	11	11	12	12	12	12	12	12	12	12
		Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

-: indicate bare soil. +: indicate growth

P-d) Solid manure – *Continued…*

Crop status +/-	Application time	Lying time Hours	2019	2020	2021	2022	2023
	Broad spreading						
-	Winter-spring	24	0	0	0	0	0
-	Winter-spring	12	0	0	0	0	0
-	Winter-spring	6	0	0	0	0	0
-	Winter-spring	4	66	66	66	66	66
+	Winter-spring	0	7	7	7	7	7
-	Spring-summer	24	0	0	0	0	0
-	Spring-summer	12	0	0	0	0	0
-	Spring-summer	6	0	0	0	0	0
-	Spring-summer	4	8	8	8	8	8
+	Spring-summer	0	7	7	7	7	7
+	Late summer-autumn	0	0	0	0	0	0
-	Late summer-autumn	24	0	0	0	0	0
-	Late summer-autumn	12	0	0	0	0	0
-	Late summer-autumn	6	0	0	0	0	0
-	Late summer-autumn	4	12	12	12	12	12
		Total	100	100	100	100	100

-: indicate bare soil. +: indicate growth

Q) Emission factor per application practice.

Q-a) Slurry untreated/acidified during storage and application.

Crop status +/-	Application time	Lying time Hours	Cattle 1985-1989	Cattle 1990-1999	Cattle 2000-2009	Cattle 2010-2023	Swine 1985-1989	Swine 1990-1999	Swine 2000-2009	Swine 2010-2023
	Injection									
-	March	0	1.6	1.6	1.6	1.6	1.8	1.8	1.8	1.8
-	April	0	1.6	1.6	1.6	1.6	1.8	1.8	1.8	1.8
+	March	0	12.0	13.0	12.0	12.0	9.3	9.6	9.6	9.7
+	April	0	14.0	14.0	13.0	14.0	9.4	9.7	9.8	9.8
+	Summer, grass injection	0	17.0	16.0	15.0	15.0	9.6	9.9	10.0	10.0
-	Summer, before winter rape	0	1.6	1.6	1.6	1.6	1.8	1.8	1.8	1.8
+	Autumn	0	17.0	16.0	15.0	15.0	9.5	9.8	10.0	10.0
-	Autumn	0	1.6	1.6	1.6	1.6	1.8	1.8	1.8	1.8
	Hose application									
-	March	24	13.0	15.0	13.0	14.0	7.5	8.5	8.3	8.6
-	March	12	10.0	11.0	9.9	11.0	6.2	7.1	6.7	7.1
-	March	6	8.3	9.3	8.1	8.8	5.2	5.8	5.6	5.8
-	March	4	7.7	8.5	7.5	8.1	4.7	5.3	5.1	5.3
-	April	24	16.0	18.0	17.0	19.0	8.1	9.3	9.5	9.8
-	May	12	13.0	14.0	13.0	15.0	7.0	8.0	8.1	8.5
-	June	6	10.0	11.0	11.0	12.0	5.8	6.6	6.6	7.0
-	July	4	9.4	10.0	9.6	10.0	5.2	5.9	6.0	6.2
+	March	0	22.0	24.0	21.0	22.0	13.0	14.0	14.0	14.0
+	April	0	26.0	27.0	25.0	27.0	13.0	14.0	15.0	15.0
+	May	0	33.0	31.0	29.0	30.0	14.0	15.0	15.0	15.0
+	Summer	0	36.0	35.0	32.0	33.0	14.0	15.0	16.0	16.0
-	Summer	24	30.0	30.0	28.0	29.0	9.1	10.0	11.0	11.0
-	Summer	12	25.0	25.0	24.0	25.0	8.6	9.9	10.0	10.0
-	Summer	6	19.0	20.0	19.0	20.0	8.0	9.1	9.5	9.6
-	Summer	4	17.0	17.0	17.0	17.0	7.3	8.3	8.7	8.8
+	Autumn	0	35.0	33.0	31.0	32.0	14.0	15.0	15.0	15.0
-	Autumn	24	27.0	26.0	26.0	26.0	9.0	10.0	11.0	11.0
-	Autumn	12	22.0	21.0	21.0	22.0	8.5	9.4	10.0	10.0
-	Autumn	6	17.0	17.0	17.0	17.0	7.6	8.3	8.9	9.0
-	Autumn	4	15.0	15.0	15.0	15.0	6.9	7.4	8.0	8.1

-: indicate bare soil. +: indicate growth

Q-a) Slurry untreated/acidified during storage and application – *Continued…*

Crop status	Application time	Lying time	Cattle				Swine			
+/-		Hours	1985-1989	1990-1999	2000-2009	2010-2023	1985-1989	1990-1999	2000-2009	2010-2023
	Broad spreading									
-	Winter-spring	< 12	1.8	1.8	1.8	1.8	15	16	17	17
-	Winter-spring	> 12	1.8	1.8	1.8	1.8	15	16	17	17
-/+	Winter-spring	0	9.3	9.6	9.6	9.7	31	32	33	33
+	Spring-summer	0	9.4	9.7	9.8	9.8	31	32	33	33
+	Late summer-autumn	0	9.6	9.9	10.0	10.0	31	32	33	33
-	Late summer-autumn	< 12	1.8	1.8	1.8	1.8	15	16	17	17
-	Late summer-autumn	> 12	9.5	9.8	10.0	10.0	15	16	17	17
-	Late summer-autumn	0	1.8	1.8	1.8	1.8	31	32	33	33

-: indicate bare soil. +: indicate growth

Q-b) Acidified slurry in barns.

Crop status +/-	Application time	Lying time Hours	Cattle 2010-2023	Swine 22010-2023
	Injection		NO	NO
	Hose application			
-	March	24	7.4	4.8
-	March	12	5.9	3.8
-	March	6	5.0	3.2
-	March	4	4.7	3.0
-	April	24	11	6.0
-	May	12	8.3	4.8
-	June	6	6.9	4.0
-	July	4	6.3	3.6
+	March	0	14	9.2
+	April	0	18	10
+	May	0	22	11
+	Summer	0	27	12
-	Summer	24	20	8.7
-	Summer	12	16	7.5
-	Summer	6	13	6.0
-	Summer	4	11	5.3
+	Autumn	0	25	12
-	Autumn	24	18	8.1
-	Autumn	12	14	6.8
-	Autumn	6	11	5.4
-	Autumn	4	9.7	4.8
	Broad spreading		NO	NO

-: indicate bare soil. +: indicate growth

1985-2006 not occurring and 2007-2010 no information about application practice for acidified slurry is available, so the same weighted EF as untreated slurry are used.

NO – not occurring

Q-c) Biogas treated slurry.

Crop status +/-	Application time	Lying time Hours	1990-1999	2000-2009	2010-2023
	Injection				
-	March	0	2.6	2.6	2.6
-	April	0	2.6	2.6	2.6
+	March	0	16	16	16
+	April	0	17	17	17
+	Summer, grass injection	0	17	17	17
-	Summer, before winter rape	0	2.6	2.6	2.6
+	Autumn	0	17	17	17
-	Autumn	0	2.6	2.6	2.6
	Hose application				
-	March	24	22	21	22
-	March	12	19	18	19
-	March	6	16	15	16
-	March	4	14	13	14
-	April	24	23	23	23
-	May	12	21	21	22
-	June	6	18	18	19
-	July	4	16	16	17
+	March	0	28	28	28
+	April	0	29	29	29
+	May	0	30	30	30
+	Summer	0	30	30	30
-	Summer	24	24	24	24
-	Summer	12	24	24	24
-	Summer	6	23	23	23
-	Summer	4	22	22	23
+	Autumn	0	30	30	30
-	Autumn	24	24	24	24
-	Autumn	12	23	24	24
-	Autumn	6	22	23	23
-	Autumn	4	20	21	21

-: indicate bare soil. +: indicate growth

Crop status +/-	Application time	Lying time Hours	1990-1999	2000-2009	2010-2023
	Broad spreading				
-	Winter-spring	< 12	32	32	32
-	Winter-spring	> 12	32	32	32
-/+	Winter-spring	0	50	50	50
+	Spring-summer	0	50	50	50
+	Late summer-autumn	0	50	50	50
-	Late summer-autumn	< 12	32	32	32
-	Late summer-autumn	> 12	32	32	32
-	Late summer-autumn	0	50	50	50

Q-d) Solid manure.

Crop status +/-	Application time	Lying time Hours	1985-1989	1990-1999	2000-2009	2010-2023
	<u>Broad spreading</u>					
-	Winter-spring	24	16	16	16	16
-	Winter-spring	12				
-	Winter-spring	6	10	10	10	10
-	Winter-spring	4	5	5	5	5
+	Winter-spring	0	16	16	16	16
-	Spring-summer	24	20	20	20	20
-	Spring-summer	12				
-	Spring-summer	6	12	12	12	12
-	Spring-summer	4	8	8	8	8
+	Spring-summer	0	20	20	20	20
+	Late summer-autumn	0	11	11	11	11
-	Late summer-autumn	24	14	14	14	14
-	Late summer-autumn	12				
-	Late summer-autumn	6	8	8	8	8
-	Late summer-autumn	4	3	3	3	3

-: indicate bare soil. +: indicate growth

No EF for lying time of 12 hours is available

R) Emission of particular matter.

TSP.

kt TSP	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Animal category																	
Dairy cattle	1.10	1.07	1.01	0.97	0.95	0.95	0.94	0.90	0.91	0.89	0.90	0.90	0.86	0.85	0.81	0.86	0.86
Non-dairy cattle	1.18	1.12	1.05	1.01	0.99	1.00	0.99	0.98	0.97	0.93	0.91	0.91	0.87	0.86	0.81	0.79	0.81
Sheep	0.002	0.002	0.002	0.003	0.003	0.004	0.004	0.004	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.005
Goats	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004
Horses	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04
Swine	2.90	2.97	2.95	2.92	2.91	3.01	3.10	3.32	3.66	3.45	3.50	3.43	3.60	3.85	3.70	3.79	4.00
Laying hens	1.06	1.06	0.96	1.04	1.03	1.08	0.96	1.07	1.05	1.32	1.16	1.20	1.07	0.93	0.95	0.93	0.89
Broilers	0.34	0.34	0.38	0.37	0.43	0.39	0.40	0.50	0.54	0.48	0.50	0.52	0.50	0.52	0.60	0.64	0.62
Turkeys	0.034	0.046	0.025	0.024	0.034	0.026	0.036	0.035	0.058	0.050	0.050	0.044	0.063	0.052	0.048	0.050	0.050
Other poultry	0.055	0.051	0.047	0.047	0.057	0.048	0.049	0.047	0.045	0.053	0.061	0.041	0.038	0.042	0.046	0.035	0.042
Other	0.03	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
TSP total	6.75	6.73	6.50	6.47	6.50	6.58	6.55	6.94	7.29	7.24	7.15	7.11	7.08	7.18	7.04	7.18	7.36

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Animal category																	
Dairy cattle	0.85	0.87	0.85	0.87	0.87	0.88	0.90	0.92	0.92	0.92	0.96	0.95	0.92	0.92	0.93	0.93	0.94
Non-dairy cattle	0.76	0.48	0.47	0.45	0.46	0.49	0.49	0.49	0.50	0.51	0.53	0.55	0.54	0.55	0.55	0.55	0.55
Sheep	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Goats	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004
Horses	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Swine	4.04	4.11	4.19	4.28	4.22	4.33	4.01	3.91	4.15	4.07	3.87	3.79	3.87	3.93	3.88	3.85	4.00
Laying hens	0.87	0.93	0.91	0.98	0.74	0.79	0.94	0.84	0.99	1.08	1.05	1.09	1.05	1.08	1.16	1.39	1.31
Broilers	0.61	0.49	0.45	0.48	0.52	0.47	0.39	0.59	0.51	0.50	0.50	0.53	0.49	0.44	0.47	0.53	0.49
Turkeys	0.049	0.036	0.050	0.056	0.035	0.045	0.050	0.058	0.058	0.046	0.045	0.028	0.024	0.025	0.034	0.025	0.027
Other poultry	0.047	0.040	0.039	0.036	0.039	0.022	0.024	0.020	0.019	0.018	0.019	0.014	0.012	0.011	0.007	0.016	0.013
Other	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
TSP total	7.31	7.03	7.06	7.23	6.96	7.13	6.92	6.92	7.25	7.24	7.07	7.04	7.01	7.06	7.13	7.40	7.43

R) *Continued…*

TSP.

kt TSP	2019	2020	2021	2022	2023
Animal category					
Dairy cattle	0.92	0.92	0.91	0.90	0.89
Non-dairy cattle	0.54	0.55	0.54	0.54	0.53
Sheep	0.003	0.003	0.003	0.003	0.003
Goats	0.0004	0.0004	0.0004	0.0004	0.0004
Horses	0.04	0.04	0.04	0.04	0.04
Swine	3.84	4.06	4.12	3.87	3.38
Laying hens	1.46	1.38	1.38	1.34	1.16
Broilers	0.59	0.56	0.56	0.61	0.62
Turkeys	0.027	0.028	0.020	0.019	0.020
Other poultry	0.012	0.010	0.005	0.004	0.002
Other	0.04	0.04	0	0	0.0001
TSP total	7.48	7.59	7.60	7.33	6.65

R) *Continued…*

PM_{10}

kt PM_{10}	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Animal category																	
Dairy cattle	0.51	0.49	0.46	0.44	0.44	0.44	0.43	0.41	0.42	0.41	0.41	0.41	0.39	0.39	0.37	0.39	0.39
Non-dairy cattle	0.54	0.52	0.49	0.47	0.45	0.46	0.45	0.45	0.45	0.43	0.42	0.42	0.40	0.39	0.37	0.37	0.37
Sheep	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
Goats	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Horses	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Swine	0.87	0.89	0.89	0.89	0.89	0.92	0.95	1.02	1.14	1.06	1.08	1.05	1.10	1.24	1.19	1.22	1.29
Laying hens	0.22	0.22	0.20	0.22	0.22	0.23	0.20	0.23	0.22	0.28	0.24	0.25	0.22	0.19	0.20	0.20	0.19
Broilers	0.17	0.17	0.19	0.19	0.22	0.20	0.20	0.25	0.27	0.24	0.25	0.26	0.25	0.26	0.30	0.32	0.31
Turkeys	0.03	0.05	0.02	0.02	0.03	0.03	0.04	0.03	0.06	0.05	0.05	0.04	0.06	0.05	0.05	0.05	0.05
Other poultry	0.06	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.04	0.04	0.04	0.05	0.03	0.04
Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
PM_{10} total	2.44	2.42	2.34	2.31	2.34	2.34	2.35	2.48	2.62	2.55	2.55	2.51	2.51	2.61	2.56	2.62	2.68

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Animal category																	
Dairy cattle	0.39	0.40	0.39	0.40	0.40	0.40	0.42	0.42	0.43	0.43	0.44	0.44	0.42	0.42	0.43	0.43	0.43
Non-dairy cattle	0.35	0.22	0.22	0.21	0.21	0.23	0.23	0.23	0.23	0.24	0.24	0.25	0.25	0.25	0.25	0.25	0.25
Sheep	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Goats	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Horses	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Swine	1.30	1.31	1.34	1.37	1.35	1.39	1.28	1.23	1.32	1.30	1.23	1.20	1.22	1.23	1.22	1.20	1.24
Laying hens	0.18	0.20	0.19	0.21	0.15	0.17	0.20	0.18	0.21	0.23	0.22	0.23	0.22	0.23	0.24	0.29	0.28
Broilers	0.30	0.24	0.23	0.24	0.26	0.24	0.19	0.30	0.26	0.25	0.25	0.26	0.25	0.22	0.23	0.27	0.25
Turkeys	0.05	0.04	0.05	0.06	0.04	0.04	0.05	0.06	0.06	0.05	0.05	0.03	0.02	0.02	0.03	0.03	0.03
Other poultry	0.05	0.04	0.04	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.01
Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
PM_{10} total	2.66	2.49	2.50	2.56	2.49	2.53	2.44	2.48	2.56	2.54	2.49	2.47	2.44	2.43	2.46	2.53	2.54

R) *Continued…*

PM_{10}.

kt PM_{10}	2019	2020	2021	2022	2023
Animal category					
Dairy cattle	0.42	0.42	0.42	0.42	0.41
Non-dairy cattle	0.25	0.25	0.25	0.25	0.24
Sheep	0.001	0.001	0.001	0.001	0.001
Goats	0.0002	0.0002	0.0002	0.0002	0.0002
Horses	0.02	0.02	0.02	0.02	0.02
Swine	1.20	1.26	1.29	1.21	1.04
Laying hens	0.31	0.29	0.29	0.28	0.24
Broilers	0.29	0.28	0.28	0.30	0.31
Turkeys	0.03	0.03	0.02	0.02	0.02
Other poultry	0.01	0.01	0.005	0.004	0.002
Other	0.02	0.02	0	0	0.00005
PM_{10} total	2.55	2.58	2.58	2.50	2.29

R) *Continued…*

PM$_{2.5.}$

kt $PM_{2.5}$	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Animal category																	
Dairy cattle	0.33	0.32	0.30	0.29	0.28	0.28	0.28	0.27	0.27	0.27	0.27	0.27	0.26	0.25	0.24	0.26	0.26
Non-dairy cattle	0.35	0.33	0.31	0.30	0.29	0.29	0.29	0.29	0.29	0.27	0.27	0.27	0.26	0.25	0.24	0.23	0.24
Sheep	0.0002	0.0002	0.0003	0.0003	0.0004	0.0004	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0006
Goats	0.00004	0.00004	0.00004	0.00004	0.00004	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00004	0.00004	0.00004	0.00004
Horses	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Swine	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.06
Laying hens	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Broilers	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Turkeys	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other poultry	0.007	0.007	0.006	0.006	0.007	0.006	0.006	0.006	0.006	0.007	0.008	0.005	0.005	0.005	0.006	0.004	0.005
Other	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
$PM_{2.5}$ total	0.78	0.76	0.72	0.69	0.69	0.69	0.68	0.68	0.68	0.67	0.67	0.66	0.64	0.64	0.61	0.63	0.63

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Animal category																	
Dairy cattle	0.25	0.26	0.25	0.26	0.26	0.26	0.27	0.27	0.28	0.28	0.29	0.29	0.28	0.27	0.28	0.28	0.28
Non-dairy cattle	0.23	0.14	0.14	0.13	0.14	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Sheep	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Goats	0.00004	0.00005	0.00005	0.00005	0.00006	0.00006	0.00007	0.00007	0.00007	0.00006	0.00006	0.00006	0.00006	0.00005	0.00005	0.00005	0.00005
Horses	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Swine	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.06
Laying hens	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Broilers	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.02
Turkeys	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.005	0.005
Other poultry	0.006	0.005	0.005	0.005	0.005	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.002	0.002
Other	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
$PM_{2.5}$ total	0.62	0.53	0.53	0.53	0.53	0.54	0.55	0.56	0.56	0.56	0.58	0.58	0.56	0.56	0.57	0.58	0.58

R) *Continued…*

PM2.5.

kt $PM_{2.5}$	2019	2020	2021	2022	2023
Animal category					
Dairy cattle	0.28	0.28	0.27	0.27	0.27
Non-dairy cattle	0.16	0.16	0.16	0.16	0.16
Sheep	0.0004	0.0004	0.0004	0.0004	0.0003
Goats	0.00005	0.00005	0.00005	0.00005	0.00005
Horses	0.01	0.01	0.01	0.01	0.01
Swine	0.05	0.06	0.06	0.05	0.05
Laying hens	0.02	0.02	0.02	0.02	0.02
Broilers	0.03	0.03	0.03	0.03	0.03
Turkeys	0.005	0.005	0.004	0.003	0.004
Other poultry	0.002	0.001	0.001	0.001	0.000
Other	0.01	0.01	0	0	0.00002
$PM_{2.5}$ total	0.57	0.57	0.56	0.55	0.54

S) Agricultural areal, ha.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Cereals, total	1 600 599	1 578 349	1 498 962	1 586 764	1 561 601	1 566 562	1 558 552	1 611 927	1 437 908	1 403 374	1 447 494	1 545 175
Wheat, total	338 536	352 964	397 525	308 118	444 502	532 949	518 715	582 504	619 360	572 359	606 666	674 207
Winter wheat	328 501	342 612	386 583	295 267	431 306	522 171	507 031	567 311	608 673	559 619	600 341	669 495
Spring wheat	10 035	10 353	10 942	12 851	13 197	10 777	11 684	15 193	10 687	12 740	6 324	4 712
Barley, total	1 093 722	1 078 103	943 112	1 154 288	987 588	901 115	935 577	910 392	709 451	699 756	714 292	763 238
Winter barley	59 509	60 504	61 412	44 085	81 899	139 468	140 195	151 328	174 568	182 087	185 419	197 545
Spring barley	1 034 213	1 017 599	881 700	1 110 203	905 689	761 647	795 382	759 064	534 883	517 670	528 872	565 693
Rye	125 918	119 939	135 505	80 280	99 961	108 545	79 622	88 178	78 273	87 937	95 720	75 495
Oats	36 410	20 843	18 063	39 958	26 495	20 212	21 462	27 646	28 165	39 757	25 530	26 396
Triticale etc	6 013	6 499	4 756	4 121	3 053	3 741	3 176	3 207	2 659	3 565	5 286	5 839
Maize for maturity	0	0	0	0	0	0	0	0	0	0	0	0
Mixed cereals	0	0	0	0	0	0	0	0	0	0	0	0
Pulses, total	126 836	144 595	203 604	146 927	122 572	114 354	98 876	118 123	120 295	100 883	74 178	69 158
Peas for maturity	0	0	0	0	0	0	0	0	0	0	0	0
Broad beans	0	0	0	0	0	0	0	0	0	0	0	0
Other pulses	0	0	0	0	0	0	0	0	0	0	0	0
Root crops, total	227 926	220 953	209 728	211 057	207 721	208 044	201 415	199 846	183 923	165 202	163 055	154 289
Potatoes	30 384	30 710	29 604	33 158	33 519	39 579	43 487	53 682	46 509	38 803	42 356	43 210
Seed potatoes	0	0	0	5 171	5 590	5 885	7 603	9 494	8 369	6 467	6 600	6 645
Potatoes for manufacturing	0	0	0	14 842	16 914	22 694	24 951	30 703	26 003	22 553	24 756	24 876
Potatoes for human consumption	0	0	0	13 145	11 015	10 999	10 934	13 485	12 137	9 782	11 000	11 690
Sugar beets	72 760	69 777	67 072	67 714	66 833	66 119	64 758	65 185	66 421	66 019	67 771	69 732
Fodder beets	124 782	120 466	113 052	110 184	107 369	102 347	93 170	80 979	70 993	60 380	52 927	41 347
Seeds for industrial use, total	220 287	230 496	260 390	203 002	233 306	272 285	280 319	181 364	164 551	170 910	154 200	108 831
Rape, total	216 821	225 995	249 616	198 532	229 980	270 099	279 158	180 444	163 835	169 338	152 074	105 293
Winter rape	34 040	17 328	36 523	27 043	77 932	159 869	202 973	117 786	136 832	95 710	108 073	68 169
Spring rape	182 780	208 667	213 093	171 489	152 048	110 230	76 185	62 658	27 003	73 628	44 001	37 124
Flax	473	0	7 771	1 914	1 446	1 365	733	785	470	889	1 195	3 438

S) *Continued…*

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Other seeds for industrial use	2 992	4 501	2 791	2 556	1 880	821	428	135	246	683	931	100
Seeds for sowing	47 042	44 555	57 487	58 201	69 412	51 743	49 729	51 667	56 150	52 794	61 556	60 964
Grass and green fodder in rotation, total	356 582	351 097	327 080	333 122	328 372	326 400	336 694	352 580	394 774	452 575	375 923	370 274
Lucerne	4 189	4 742	4 555	4 608	6 373	8 494	10 810	10 838	11 650	10 629	10 099	11 145
Maize for green fodder	20 374	24 715	24 967	16 607	17 106	18 735	19 164	20 245	26 187	31 269	36 583	41 652
Cereals and pulses for green fodder	50 629	55 220	47 416	52 819	50 104	47 772	53 621	63 761	68 015	77 696	87 893	58 997
Grass and clover in rotation	281 389	266 420	250 142	259 088	254 788	251 399	253 098	257 736	288 923	332 980	241 348	258 480
Horticultural crops, total	31 047	31 219	26 161	26 985	27 402	27 792	27 347	28 839	27 512	25 442	24 719	22 808
Vegetables grown in the open, total	7 282	7 491	7 013	7 613	7 143	7 314	6 987	7 642	6 442	6 530	7 055	7 041
Peas for canning	11 194	11 716	7 456	7 949	8 992	8 791	8 716	8 723	8 977	6 103	5 529	3 758
Fruits and berries, total	8 689	8 091	7 958	7 753	7 549	7 892	7 944	8 975	8 255	8 665	8 367	8 457
Apples	3 615	3 338	3 172	3 105	2 772	2 726	2 462	3 006	2 209	2 061	1 658	1 854
Pears	444	367	383	417	344	351	497	436	438	328	545	469
Strawberries	1 364	1 372	1 330	1 198	1 188	1 096	1 049	992	1 018	947	1 135	983
Cherries	1 973	1 674	1 784	0	0	0	0	0	2 022	2 441	2 654	2 823
Black current	773	0	844	0	0	0	0	0	1 919	2 351	1 827	1 783
Redcurrant	0	0	0	0	0	0	0	0	0	0	0	0
Other fruits and berries	519	1 341	445	3 033	3 245	3 719	3 936	4 541	649	537	548	543
Bulbs and flowers	362	574	324	411	368	323	291	382	353	253	332	255
Nursery area	3 521	3 347	3 410	3 260	3 350	3 471	3 409	3 117	3 485	3 892	3 437	3 298
Permanent grass land out of rotation	220 564	214 446	210 480	216 775	219 085	217 235	212 030	207 932	197 229	316 668	207 122	192 851
Christmas trees	0	0	0	0	0	0	0	0	0	0	0	0
Fallow land	0	0	0	0	0	0	0	0	0	0	216 493	190 701
Fallow land with subsidy	0	0	0	0	0	0	0	0	0	0	0	0
Fallow land without subsidy	0	0	0	0	0	0	0	0	0	0	0	0
Other crops	3 217	3 199	3 831	3 769	4 656	3 861	4 694	4 047	156 217	3 326	1 308	982
Total agricultural area	2 834 100	2 818 910	2 797 723	2 786 603	2 774 128	2 788 276	2 769 657	2 756 327	2 738 559	2 691 174	2 726 048	2 716 034

S) *Continued…*

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Cereals, total	1 555 265	1 493 983	1 447 749	1 499 714	1 536 516	1 531 443	1 487 312	1 485 639	1 510 833	1 512 814	1 445 158	1 505 210
Wheat, total	684 835	673 209	619 381	619 160	632 704	575 749	663 610	665 869	678 735	692 337	691 670	649 440
Winter wheat	671 570	666 826	611 437	611 183	624 198	564 819	651 023	650 114	666 512	682 080	683 764	638 724
Spring wheat	13 264	6 383	7 944	7 977	8 506	10 930	12 587	15 755	12 223	10 257	7 906	10 716
Barley, total	738 994	659 836	701 188	731 088	737 307	818 635	705 237	693 337	702 845	688 398	626 232	707 395
Winter barley	176 416	162 039	150 508	144 514	146 219	116 840	129 750	121 978	139 855	161 241	168 824	126 516
Spring barley	562 578	497 796	550 680	586 574	591 088	701 795	575 487	571 359	562 991	527 158	457 408	580 879
Rye	88 320	103 171	49 180	50 472	65 059	46 205	32 666	31 430	28 474	29 755	30 047	30 975
Oats	30 059	28 614	25 784	44 448	59 498	54 725	49 064	54 588	58 261	60 288	55 563	71 873
Triticale etc	13 058	29 153	52 216	54 546	41 948	36 130	36 735	40 414	42 518	32 869	32 164	36 613
Maize for maturity	0	0	0	0	0	0	0	0	0	0	0	0
Mixed cereals	0	0	0	0	0	0	0	0	0	9 168	9 482	8 913
Pulses, total	95 256	106 051	65 762	35 590	31 964	40 184	31 356	26 593	15 819	11 353	5 639	4 910
Peas for maturity	0	0	0	0	0	0	0	0	0	8 839	4 073	4 063
Broad beans	0	0	0	0	0	0	0	0	0	0	0	0
Other pulses	0	0	0	0	0	0	0	0	0	0	0	0
Root crops, total	146 225	133 387	123 761	115 433	107 811	105 410	93 637	96 027	92 895	83 642	84 343	83 768
Potatoes	39 316	35 502	37 946	38 688	38 186	37 651	36 046	41 050	40 482	37 954	41 224	42 379
Seed potatoes	5 426	4 827	4 606	4 522	4 757	3 414	3 359	5 079	5 094	4 032	4 654	4 380
Potatoes for manufacturing	23 794	21 969	22 376	22 642	21 620	20 484	20 461	19 392	19 110	18 712	20 880	20 018
Potatoes for human consumption	10 096	8 705	10 964	11 524	11 809	13 754	12 226	16 578	16 278	15 210	15 689	17 981
Sugar beets	69 495	65 698	62 898	59 167	56 323	57 806	49 600	48 745	47 439	41 653	39 301	36 182
Fodder beets	37 414	32 188	22 917	17 577	13 302	9 953	7 991	6 233	4 974	4 035	3 819	5 206
Seeds for industrial use, total	107 027	115 751	150 515	104 175	80 047	84 025	106 488	121 755	113 571	124 840	180 072	173 580
Rape, total	103 514	111 879	139 810	99 125	78 608	83 758	106 343	121 626	113 412	124 469	179 842	172 994
Winter rape	73 217	90 272	104 775	81 178	70 947	77 561	102 207	120 281	109 271	121 948	178 812	172 606
Spring rape	30 297	21 607	35 035	17 946	7 661	6 196	4 136	1 345	4 141	2 521	1 030	388
Flax	3 461	3 871	10 698	5 029	1 422	221	117	113	98	212	59	211

S) *Continued…*

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Other seeds for industrial use	52	0	7	21	17	47	28	16	60	160	171	375
Seeds for sowing	61 212	84 515	80 979	78 949	84 958	71 040	87 193	90 781	96 122	103 941	87 262	82 058
Grass and green fodder in rotation, total	386 863	419 300	410 478	432 741	436 932	429 823	444 303	431 941	464 164	474 084	471 359	515 306
Lucerne	7 342	6 850	5 514	5 245	3 451	3 566	3 946	4 147	4 575	3 982	3 682	3 756
Maize for green fodder	42 701	46 992	48 452	61 493	78 814	95 741	118 267	129 317	131 027	135 245	144 869	159 030
Cereals and pulses for green fodder	101 124	115 657	117 782	118 763	113 504	112 469	110 089	102 041	75 512	63 998	60 348	52 251
Grass and clover in rotation	235 696	249 801	238 729	247 241	241 163	218 048	212 002	196 436	253 050	270 859	262 460	300 270
Horticultural crops, total	20 689	20 703	21 132	21 678	20 880	19 478	20 889	20 522	20 113	20 429	20 556	22 154
Vegetables grown in the open, total	6 251	6 084	6 157	6 479	6 015	6 066	6 396	6 656	6 432	7 089	7 077	7 456
Peas for canning	3 124	3 962	4 172	4 149	3 441	2 689	3 386	2 979	2 999	2 841	2 741	3 592
Fruits and berries, total	7 874	7 505	7 683	8 010	8 447	7 976	8 330	7 816	8 237	8 083	8 322	8 294
Apples	1 697	1 660	1 623	1 679	1 783	1 574	1 624	1 673	1 751	1 645	1 812	1 797
Pears	430	555	431	441	469	420	457	439	416	413	465	442
Strawberries	1 095	983	991	984	1 066	788	805	899	1 091	1 277	1 135	1 144
Cherries	2 594	2 591	2 756	2 802	2 703	2 671	2 767	2 513	2 132	2 128	2 167	1 950
Black current	1 531	1 280	1 411	1 492	1 850	1 939	2 028	1 976	2 000	1 846	1 855	2 071
Redcurrant	0	0	0	0	0	0	0	0	0	485	537	426
Other fruits and berries	523	435	472	612	576	584	648	756	848	289	350	463
Bulbs and flowers	180	156	194	175	160	148	150	128	127	141	161	293
Nursery area	3 261	2 997	2 925	2 866	2 817	2 600	2 626	2 503	2 318	2 275	2 255	2 519
Permanent grass land out of rotation	167 600	156 260	159 530	166 261	173 702	177 546	177 635	172 536	192 968	189 384	196 630	189 962
Christmas trees	0	0	0	0	0	0	0	0	0	15 119	14 523	17 015
Fallow land	147 400	141 432	182 905	191 295	201 817	204 721	206 584	196 972	175 200	180 915	164 518	80 547
Fallow land with subsidy	0	0	0	0	0	0	0	0	0	167 502	153 570	70 662
Fallow land without subsidy	0	0	0	0	0	0	0	0	0	13 413	10 948	9 885
Other crops	477	468	1 236	1 146	940	1 834	2 309	2 538	25 551	9 105	7 226	10 400
Total agricultural area	2 688 014	2 671 850	2 644 048	2 646 982	2 675 566	2 665 507	2 657 706	2 645 304	2 707 236	2 725 626	2 677 284	2 684 910

S) *Continued…*

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cereals, total	1 460 981	1 469 168	1 490 606	1 495 177	1 434 781	1 474 773	1 453 896	1 466 687	1 452 529	1 420 173	1 378 543	1 363 958
Wheat, total	725 861	757 663	744 708	619 705	570 854	668 441	621 374	585 068	593 477	439 567	571 698	501 733
Winter wheat	716 482	743 911	724 487	588 724	542 051	651 530	608 733	568 815	579 495	406 774	559 038	483 445
Spring wheat	9 379	13 753	20 221	30 981	28 803	16 910	12 641	16 253	13 982	32 793	12 660	18 288
Barley, total	584 485	568 070	602 025	727 661	689 528	635 743	639 131	709 662	673 371	789 621	590 629	651 545
Winter barley	141 270	142 560	130 882	104 214	110 853	145 209	114 178	111 653	126 959	81 931	99 794	87 665
Spring barley	443 215	425 510	471 143	623 447	578 675	490 533	524 952	598 008	546 412	707 690	490 836	563 879
Rye	42 197	51 336	56 097	57 537	88 181	104 093	125 540	98 977	108 749	89 981	144 906	115 002
Oats	53 382	41 907	42 304	51 010	53 488	34 830	37 797	51 725	56 740	80 153	50 428	74 633
Triticale etc	43 880	36 137	26 581	20 007	12 485	14 539	15 416	8 994	8 164	7 331	8 819	6 479
Maize for maturity	7 104	9 129	9 693	12 725	11 711	9 421	7 210	5 728	5 016	6 158	4 940	6 195
Mixed cereals	4 073	4 926	9 199	6 531	8 533	7 707	7 427	6 535	7 012	7 361	7 123	8 372
Pulses, total	6 332	10 349	7 109	6 252	7 912	8 793	12 229	14 864	20 627	33 983	21 524	27 273
Peas for maturity	5 056	8 596	5 052	4 342	5 191	4 063	4 595	4 786	5 633	7 102	4 862	7 404
Broad beans	0	0	0	0	0	0	0	0	14 612	26 577	16 363	19 170
Other pulses	0	0	0	0	0	0	0	0	382	305	299	700
Root crops, total	80 998	81 331	84 462	89 077	84 809	85 183	71 771	82 771	84 735	92 009	88 455	99 867
Potatoes	38 067	38 138	40 532	41 622	40 392	42 617	41 579	43 885	47 038	48 635	53 589	62 679
Seed potatoes	4 551	5 189	5 151	6 535	4 957	5 302	5 851	5 550	6 557	7 048	7 063	9 205
Potatoes for manufacturing	17 728	16 637	18 948	21 322	21 217	21 562	22 012	25 543	27 250	28 786	34 623	42 304
Potatoes for human consumption	15 787	16 312	16 433	13 764	14 218	15 753	13 716	12 793	13 230	12 801	11 903	11 170
Sugar beets	37 674	39 074	39 945	42 893	38 680	35 859	25 004	34 550	33 114	39 369	29 672	33 064
Fodder beets	5 257	4 118	3 985	4 562	5 736	6 708	5 188	4 336	4 583	4 006	5 193	4 123
Seeds for industrial use, total	161 779	165 721	152 834	127 316	175 580	166 264	193 640	165 427	178 652	146 471	166 714	147 031
Rape, total	160 940	164 808	152 220	126 915	175 117	165 595	193 234	164 285	177 688	145 347	165 296	145 726
Winter rape	160 326	163 436	150 402	124 449	173 746	164 221	192 535	163 749	176 829	144 254	164 480	144 708
Spring rape	613	1 372	1 818	2 467	1 371	1 375	699	536	860	1 094	816	1 018
Flax	134	90	39	0	0	100	0	0	107	0	831	72

S) *Continued…*

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Other seeds for industrial use	706	823	575	401	463	569	407	1 142	857	1 123	664	1 233
Seeds for sowing	90 112	66 655	66 122	75 529	79 616	77 825	74 512	72 835	82 251	102 860	113 341	106 308
Grass and green fodder in rotation, total	536 024	562 358	566 426	569 415	565 725	560 820	492 732	510 907	488 148	494 075	524 592	520 873
Lucerne	5 366	6 405	6 926	4 715	3 715	3 814	2 579	1 923	1 939	1 372	800	873
Maize for green fodder	168 917	172 168	173 693	183 570	182 935	183 370	177 908	178 540	165 338	177 678	186 009	188 359
Cereals and pulses for green fodder	55 851	62 845	56 672	54 333	58 945	61 100	56 621	60 461	48 686	50 878	54 484	49 259
Grass and clover in rotation	305 889	320 940	329 135	326 797	320 131	312 536	255 623	269 983	272 185	264 146	283 299	282 383
Horticultural crops, total	21 124	20 130	19 852	19 060	18 733	20 417	19 737	20 126	20 596	20 576	20 269	19 892
Vegetables grown in the open, total	7 726	8 043	8 209	7 382	7 675	9 209	8 331	8 812	9 576	9 779	9 628	9 476
Peas for canning	3 737	2 677	2 935	2 837	2 209	2 505	2 749	3 241	3 430	3 136	3 813	3 228
Fruits and berries, total	7 733	7 797	7 596	7 508	7 604	7 611	6 348	6 036	5 562	5 633	5 098	5 218
Apples	1 736	1 684	1 550	1 703	1 563	1 484	1 501	1 490	1 471	1 677	1 495	1 489
Pears	372	357	336	344	299	308	317	317	333	305	312	305
Strawberries	985	1 137	1 160	1 185	1 119	1 455	1 227	1 186	1 275	1 269	1 130	1 106
Cherries	1 864	1 743	1 466	1 401	1 380	1 317	1 059	1 047	870	639	667	640
Black current	1 849	1 935	2 041	1 855	2 167	1 719	1 121	755	588	541	453	463
Redcurrant	394	315	341	303	253	247	164	239	265	394	227	185
Other fruits and berries	533	627	702	716	823	1 082	960	1 002	761	809	815	1 031
Bulbs and flowers	101	92	71	86	46	31	39	28	51	55	74	71
Nursery area	1 827	1 521	1 041	1 247	1 199	1 061	2 270	2 009	1 977	1 974	1 656	1 899
Permanent grass land out of rotation	192 433	199 859	186 652	200 413	195 484	192 617	254 770	225 620	234 680	212 657	206 687	222 405
Christmas trees	18 538	19 521	17 609	20 593	18 928	23 461	22 101	20 908	21 603	23 693	19 216	22 319
Fallow land	38 810	34 740	25 056	24 569	26 239	21 783	26 546	33 936	37 263	76 377	76 973	81 727
Fallow land with subsidy	5 699	9 874	4 367	5 018	9 123	4 930	4 501	6 079	5 461	9 253	8 639	8 301
Fallow land without subsidy	33 110	24 866	20 689	19 551	17 116	16 853	22 045	27 857	31 802	67 124	68 333	73 426
Other crops	18 559	16 569	23 217	17 230	20 010	20 091	11 013	11 011	10 205	9 578	9 704	8 334
Total agricultural area	2 625 690	2 646 400	2 639 944	2 644 631	2 627 817	2 652 026	2 632 947	2 625 093	2 631 289	2 632 453	2 625 965	2 619 987

S) *Continued…*

	2021	2022	2023
Cereals, total	1 362 954	1 305 414	1 241 928
Wheat, total	545 707	495 908	493 479
Winter wheat	519 634	478 440	481 072
Spring wheat	26 073	17 468	12 407
Barley, total	620 859	612 236	564 433
Winter barley	78 970	63 865	58 894
Spring barley	541 890	548 371	505 538
Rye	108 310	111 989	107 602
Oats	65 448	62 338	55 776
Triticale etc	6 755	5 111	4 856
Maize for maturity	6 249	8 090	6 546
Mixed cereals	9 626	9 743	9 236
Pulses, total	34 145	40 138	45 297
Peas for maturity	9 862	14 725	19 601
Broad beans	21 520	22 493	23 380
Other pulses	2 763	2 919	2 316
Root crops, total	92 110	91 859	96 420
Potatoes	55 019	57 229	61 139
Seed potatoes	8 675	7 409	9 089
Potatoes for manufacturing	40 286	43 009	46 406
Potatoes for human consumption	6 058	6 811	5 644
Sugar beets	33 421	31 194	31 079
Fodder beets	3 670	3 436	4 201
Seeds for industrial use, total	166 299	198 056	213 304
Rape, total	165 478	196 384	211 664
Winter rape	164 230	194 805	210 574
Spring rape	1 249	1 578	1 090
Flax	51	134	114

	2021	2022	2023
Other seeds for industrial use	770	1 538	1 526
Seeds for sowing	109 817	124 346	108 053
Grass and green fodder in rotation, total	493 349	479 590	474 209
Lucerne	570	513	480
Maize for green fodder	170 578	160 862	177 846
Cereals and pulses for green fodder	47 168	48 605	42 906
Grass and clover in rotation	275 034	269 610	252 977
Horticultural crops, total	19 513	19 089	17 806
Vegetables grown in the open, total	9 301	9 292	9 344
Peas for canning	3 275	2 698	831
Fruits and berries, total	5 028	5 019	5 229
Apples	1 520	1 507	1 461
Pears	311	296	318
Strawberries	982	1 061	982
Cherries	662	478	485
Black current	369	414	354
Redcurrant	136	142	124
Other fruits and berries	1 046	1 121	1 506
Bulbs and flowers	197	215	208
Nursery area	1 713	1 866	2 194
Permanent grass land out of rotation	234 288	233 240	226 438
Christmas trees	20 398	24 298	21 962
Fallow land	77 065	101 180	167 654
Fallow land with subsidy	8 420	9 416	24 907
Fallow land without subsidy	68 646	91 765	142 747
Other crops	8 461	7 035	7 875
Total agricultural area	2 618 399	2 624 245	2 620 947

T) Number of operations; soil cultivation, harvesting, cleaning and drying.

T-a) Soil cultivation.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Winter wheat	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	8	8	8
Spring wheat	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Rye	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	7	7	7
Winter barley	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6	6
Spring barley	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6	6
Oats	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	5.5	5.5	5.5
Triticale etc	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	7	7	7
Seed potatoes	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
Potatoes for manufacturing	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	16	17	17
Potatoes for human consumption	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Sugar beets	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Fodder beets	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	10
Winter rape	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9
Spring rape	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6	6
Flax	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	7	7.5	7.5
Other seeds for industrial use	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	7	7.5	7.5
Seeds for sowing	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	3.6	3.6	3.6
Lucerne	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Maize for green fodder	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Cereals and pulses for green fodder	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	6.3	6.3	6.3
Pulses	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	6.3	6.3	6.3
Grass and clover in rotation	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	1.8	1.8	1.8
Peas for canning	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6	6
Broad beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Permanent grass land out of rotation	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	1.8	1.8	1.8

T-a) Soil cultivation. *Continued…*

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Winter wheat	8	8	8	8	8	8	8	8	8	8	8	8	10	10	10	9	9	9	9
Spring wheat	6	6	6	6	6	6	6	6	6	6	6	6	7	7	6	6	6	6	6
Rye	7	7	7	7	7	7	7	7	7	7	7	7	9	9	9	8	8	8	8
Winter barley	6	6	6	6	6	6	6	6	6	6	6	6	8	8	8	7	7	7	7
Spring barley	6	6	6	6	6	6	6	6	6	6	6	6	7	7	6	6	6	6	6
Oats	5.5	5.5	5.5	5.5	5.5	5.5	6	6	6	6	6	6	6	6	5	5	5	5	5
Triticale etc	7	7	7	7	7	7	7	7	7	7	7	7	10	10	10	9	9	9	9
Seed potatoes	14.5	14.5	14.5	14.5	16.5	20.5	19	19	19	19	19	19	19	19	19	19	19	19	19
Potatoes for manufacturing	17	17	17	17	19	22	19	19	19	19	19	19	20	20	20	20	20	20	20
Potatoes for human consumption	15	15	15	15	17	20	16	16	16	16	16	16	16	16	16	16	16	16	16
Sugar beets	12	12	12	12	12	12	12	12	12	12	13	13	14	14	14	14	12	12	12
Fodder beets	10	10	11	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12
Winter rape	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10
Spring rape	6	6	6	6	6	7	7	7	7	7	5	5	5	5	5	5	5	5	5
Flax	7.5	7.5	7.5	7.5	7.5	8	8	8	8	8	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Other seeds for industrial use	7.5	7.5	7.5	7.5	7.5	8	8	8	8	8	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Seeds for sowing	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	5	4	4	4.5	4.8	4.8	5.2	6.5	6.5	6.5
Lucerne	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Maize for green fodder	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Cereals and pulses for green fodder	6.3	6.3	6.3	6	6	6	6	6	6	6	6	6	6.3	6	6	6	6	6	6
Pulses	6.3	6.3	6.3	6	6	6	6	6	6	6	6	6	6.3	6	6	6	6	6	6
Grass and clover in rotation	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	2.7	3.5	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Peas for canning	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Broad beans	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7	7	7	7	0
Permanent grass land out of rotation	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

T-b) Harvesting

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Winter wheat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spring wheat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rye	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Winter barley	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spring barley	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oats	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Triticale etc	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Seed potatoes	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Potatoes for manufacturing	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Potatoes for human consumption	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sugar beets	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fodder beets	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Winter rape	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spring rape	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
Flax	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.5	1.5	1.5
Other seeds for industrial use	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.5	1.5	1.5
Seeds for sowing	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Lucerne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize for green fodder	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cereals and pulses for green fodder	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1	1	1
Pulses	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1	1	1
Grass and clover in rotation	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Peas for canning	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Broad beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Permanent grass land out of rotation	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0

T-b) Harvesting. *Continued…*

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Winter wheat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spring wheat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rye	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Winter barley	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spring barley	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oats	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Triticale etc	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Seed potatoes	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Potatoes for manufacturing	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Potatoes for human consumption	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sugar beets	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fodder beets	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Winter rape	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spring rape	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Flax	1.5	1.5	1.5	1.5	1.5	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Other seeds for industrial use	1.5	1.5	1.5	1.5	1.5	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Seeds for sowing	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.5	1.5	1.5	1.5	1.5	1.5
Lucerne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize for green fodder	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cereals and pulses for green fodder	1	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Pulses	1	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Grass and clover in rotation	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3.4	2.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Peas for canning	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Broad beans	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
Permanent grass land out of rotation	0	0	0	0	0	0	0	0	0	1.3	2	2	2	2	2	2	2	2	2

T-c) Cleaning.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Winter wheat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spring wheat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rye	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Winter barley	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spring barley	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oats	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Triticale etc	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Seed potatoes	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Potatoes for manufacturing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potatoes for human consumption	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Sugar beets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fodder beets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Winter rape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spring rape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other seeds for industrial use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Seeds for sowing	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lucerne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize for green fodder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cereals and pulses for green fodder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grass and clover in rota-tion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peas for canning	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Broad beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Permanent grass land out of rotation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

T-c) Cleaning. *Continued…*

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Winter wheat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spring wheat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rye	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Winter barley	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spring barley	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oats	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Triticale etc	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Seed potatoes	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Potatoes for manufacturing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potatoes for human consumption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sugar beets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fodder beets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Winter rape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spring rape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other seeds for industrial use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Seeds for sowing	1	1	1	1	1	1	1	1	1	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Lucerne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize for green fodder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cereals and pulses for green fodder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grass and clover in rotation	0	0	0	0	0	0	0	0	0	1.5	1.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Peas for canning	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broad beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Permanent grass land out of rotation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

T-d) Drying

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Winter wheat	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Spring wheat	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Rye	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Winter barley	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Spring barley	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Oats	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Triticale etc	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Seed potatoes	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Potatoes for manufacturing	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Potatoes for human consumption	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sugar beets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fodder beets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Winter rape	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Spring rape	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Flax	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Other seeds for industrial use	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Seeds for sowing	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lucerne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize for green fodder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cereals and pulses for green fodder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grass and clover in rota-tion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peas for canning	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Broad beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Permanent grass land out of rotation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

T-d) Drying. *Continued…*

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Winter wheat	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Spring wheat	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Rye	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Winter barley	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Spring barley	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Oats	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Triticale etc	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Seed potatoes	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Potatoes for manufacturing	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Potatoes for human consumption	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sugar beets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fodder beets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Winter rape	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Spring rape	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Flax	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Other seeds for industrial use	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Seeds for sowing	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lucerne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize for green fodder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cereals and pulses for green fodder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grass and clover in rotation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peas for canning	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Broad beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Permanent grass land out of rotation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

U) Emission of different pollutants from field burning of agricultural residue.

Pollutants	Unit	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
NH_3	kt	1.48	1.26	1.19	0.87	0.91	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04
CH_4	kt	3.51	2.99	2.82	2.06	2.16	0.07	0.07	0.06	0.07	0.06	0.07	0.07	0.07	0.09	0.08	0.08	0.09
N_2O	kt	0.055	0.047	0.045	0.032	0.034	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
NO_x	kt	1.42	1.21	1.14	0.83	0.87	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04
CO	kt	41.10	34.98	33.02	24.08	25.27	0.78	0.79	0.69	0.77	0.74	0.84	0.83	0.88	1.04	0.98	0.98	1.02
CO_2	kt	881.16	749.95	708.01	516.28	541.81	16.70	16.88	14.80	16.49	15.87	17.94	17.80	18.79	22.28	21.06	21.02	21.77
SO_2	kt	0.31	0.26	0.25	0.18	0.19	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NMVOC	kt	0.31	0.26	0.25	0.18	0.19	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
PM																		
TSP	kt	3.57	3.04	2.87	2.09	2.20	0.07	0.07	0.06	0.07	0.06	0.07	0.07	0.08	0.09	0.09	0.09	0.09
PM_{10}	kt	3.51	2.99	2.82	2.06	2.16	0.07	0.07	0.06	0.07	0.06	0.07	0.07	0.07	0.09	0.08	0.08	0.09
$PM_{2.5}$	kt	3.33	2.83	2.67	1.95	2.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.08
BC	kt	0.31	0.26	0.25	0.18	0.19	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Metals																		
Pb	t	0.07	0.06	0.05	0.04	0.04	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
Cd	t	0.542	0.462	0.436	0.318	0.333	0.010	0.010	0.009	0.010	0.010	0.011	0.011	0.012	0.014	0.013	0.013	0.013
Hg	t	0.086	0.073	0.069	0.051	0.053	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
As	t	0.004	0.003	0.003	0.002	0.002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cr	t	0.049	0.042	0.040	0.029	0.030	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ni	t	0.032	0.027	0.026	0.019	0.020	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Se	t	0.012	0.010	0.010	0.007	0.008	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003
Zn	t	0.345	0.294	0.277	0.202	0.212	0.007	0.007	0.006	0.006	0.006	0.007	0.007	0.007	0.009	0.008	0.008	0.009
Cu	t	0.045	0.038	0.036	0.026	0.028	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Dioxin	g I-TEQ	0.38	0.32	0.31	0.23	0.24	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
PAH																		
(a)[1]	t	0.25	0.22	0.20	0.15	0.16	0.005	0.005	0.004	0.005	0.005	0.01	0.01	0.01	0.01	0.01	0.01	0.01
(b)[1]	t	0.70	0.60	0.56	0.41	0.43	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
(k)[1]	t	0.30	0.25	0.24	0.17	0.18	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
(1,2,3)[1]	t	0.41	0.35	0.33	0.24	0.25	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HCB	kg	2.22	1.90	1.80	1.33	1.40	0.08	0.08	0.08	0.09	0.08	0.10	0.09	0.10	0.12	0.12	0.12	0.12
PCB	kg	0.002	0.002	0.002	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

[1] (a) Benzo(a)pyrene (b) Benzo(b)fluoranthene (k) Benzo(k)fluoranthene (1,2,3) Indeno(1.2.3-cd)pyrene

U) *Continued…*

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NH_3	kt	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
CH_4	kt	0.07	0.08	0.09	0.09	0.09	0.08	0.08	0.09	0.07	0.07	0.08	0.08	0.08	0.08	0.07	0.08	0.08
N_2O	kt	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
NO_x	kt	0.03	0.03	0.04	0.04	0.04	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
CO	kt	0.87	0.99	1.03	1.05	1.05	0.93	0.90	1.04	0.79	0.79	0.89	0.94	0.94	0.88	0.83	0.94	0.97
CO_2	kt	18.66	21.26	22.13	22.42	22.43	19.93	19.21	22.28	16.99	16.83	18.97	20.12	20.25	18.85	17.84	20.22	20.83
SO_2	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NMVOC	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
PM																		
TSP	kt	0.08	0.09	0.09	0.09	0.09	0.08	0.08	0.09	0.07	0.07	0.08	0.08	0.08	0.08	0.07	0.08	0.08
PM_{10}	kt	0.07	0.08	0.09	0.09	0.09	0.08	0.08	0.09	0.07	0.07	0.08	0.08	0.08	0.08	0.07	0.08	0.08
$PM_{2.5}$	kt	0.07	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.06	0.06	0.07	0.08	0.08	0.07	0.07	0.08	0.08
BC	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Metals																		
Pb	t	0.001	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.002	0.002
Cd	t	0.011	0.013	0.014	0.014	0.014	0.012	0.012	0.014	0.010	0.010	0.012	0.012	0.012	0.012	0.011	0.012	0.013
Hg	t	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
As	t	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cr	t	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ni	t	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Se	t	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0002	0.0003	0.0003
Zn	t	0.007	0.008	0.009	0.009	0.009	0.008	0.008	0.009	0.007	0.007	0.007	0.008	0.008	0.007	0.007	0.008	0.008
Cu	t	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Dioxin	g I-TEQ	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03
PAH																		
(a)[1]	t	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
(b)[1]	t	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.02	0.02
(k)[1]	t	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
(1,2,3)[1]	t	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HCB	kg	0.10	0.12	0.13	0.13	0.13	0.11	0.11	0.12	0.09	0.09	0.10	0.11	0.11	0.10	0.10	0.11	0.12
PCB	kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

[1] (a) Benzo(a)pyrene (b) Benzo(b)fluoranthene (k) Benzo(k)fluoranthene (1,2,3) Indeno(1.2.3-cd)pyrene

U) *Continued…*

		2019	2020	2021	2022	2023
NH_3	kt	0.04	0.04	0.04	0.05	0.04
CH_4	kt	0.10	0.10	0.10	0.11	0.09
N_2O	kt	0.002	0.002	0.002	0.002	0.001
NO_x	kt	0.04	0.04	0.04	0.04	0.04
CO	kt	1.13	1.13	1.15	1.27	1.03
CO_2	kt	24.28	24.18	24.61	27.25	22.12
SO_2	kt	0.01	0.01	0.01	0.01	0.01
NMVOC	kt	0.01	0.01	0.01	0.01	0.01
PM						
TSP	kt	0.10	0.10	0.10	0.11	0.09
PM_{10}	kt	0.10	0.10	0.10	0.11	0.09
$PM_{2.5}$	kt	0.09	0.09	0.09	0.10	0.08
BC	kt	0.01	0.01	0.01	0.01	0.01
Metals						
Pb	t	0.002	0.002	0.002	0.002	0.002
Cd	t	0.015	0.015	0.015	0.017	0.014
Hg	t	0.002	0.002	0.002	0.003	0.002
As	t	0.0001	0.0001	0.0001	0.0001	0.0001
Cr	t	0.001	0.001	0.001	0.002	0.001
Ni	t	0.001	0.001	0.001	0.001	0.001
Se	t	0.0003	0.0003	0.0003	0.0004	0.0003
Zn	t	0.010	0.009	0.010	0.011	0.009
Cu	t	0.001	0.001	0.001	0.001	0.001
Dioxin	g I-TEQ	0.03	0.03	0.03	0.04	0.03
PAH						
(a)[1]	t	0.01	0.01	0.01	0.01	0.01
(b)[1]	t	0.02	0.02	0.02	0.02	0.02
(k)[1]	t	0.01	0.01	0.01	0.01	0.01
(1,2,3)[1]	t	0.01	0.01	0.01	0.01	0.01
HCB	kg	0.14	0.14	0.14	0.16	0.13
PCB	kg	<0.001	<0.001	<0.001	<0.001	<0.001

[1] (a) Benzo(a)pyrene (b) Benzo(b)fluoranthene (k) Benzo(k)fluoranthene (1,2,3) Indeno(1.2.3-cd)pyrene

V) Gross energy per kg DM for dairy cattle. MJ per kg DM.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
MJ per kg DM	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
MJ per kg DM	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9

	2019	2020	2021	2022	2023
MJ per kg DM	18.9	18.9	18.9	18.9	18.9

W) Feeding plans - average feeding level.

Winter feeding plans		Feeding code	Pct. dm	Pct. Crude protein	Pct. Raw fat	Pct. Raw ashes	Pct. Carbon-hydrates	FU per kg dm	kg feed per day	MJ per day	MJ per FU
Heifers:	Straw	781	85.0	4.0	1.9	4.5	89.6	0.2	33.4	571.8	
	Maize silage	593	31.0	8.7	2.2	4.2	84.9	0.9	57.5	1 009.0	
	Toasted soya	155	87.5	49.1	3.2	7.4	40.3	1.4	8.1	161.7	
	Total	-	-	-	-	-	-	-	99.0	1 742.4	**25.8**
Suckling cows:	Straw	781	85.0	4.0	1.9	4.5	89.6	0.2	1.6	119.1	
Period 1 (2 mth)	Toasted soya	155	87.5	49.1	3.2	7.4	40.3	1.4	3.4	49.6	
	Barley	201	85.0	11.2	2.9	2.2	83.7	1.1	1.8	29.2	
Period 2 (4 mth)	Straw	781	85.0	4.0	1.9	4.5	89.6	0.2	3.2	238.2	
	Toasted soya	155	87.5	49.1	3.2	7.4	40.3	1.4	3.0	29.1	
	Barley	202	85.0	11.2	2.9	2.2	83.7	1.1	3.2	52.0	
	Total	-	-	-	-	-	-	-	15.2	517.1	**34.0**
Horses:	Straw	781	85.0	4.0	1.9	4.5	89.6	0.2	4.0	58.2	
	Hay	665	85.0	12.1	2.6	7.7	77.6	0.6	3.0	44.0	
	Oat	202	86.0	12.1	5.7	2.7	79.5	0.9	2.5	40.1	
	Supplemental		86.4	15.4	4.3	6.6	73.7	1.0	1.0	15.5	
	Total	-	-	-	-	-	-	-	-	157.7	**29.8**
Sheep and Goats:	Straw	781	85.0	4.0	1.9	4.5	89.6	0.2	1.0	14.6	
	Toasted soya	155	87.5	49.1	3.2	7.4	40.3	1.4	0.1	1.8	
	Barley	202	85.0	11.2	2.9	2.2	83.7	1.1	0.4	6.2	
	Grass pills (dried)	707	92.0	17.0	3.1	11.0	68.9	0.6	1.0	15.7	
	Total	-	-	-	-	-	-	-	-	38.2	**30.0**
Summer grazing[1]											
Grazing	Clover grass. 2 weeks old	422	18.0	22.0	4.1	9.4	64.5	1.0	1.0	18.8	
	Total	-	-	-	-	-	-	-	1.0	18.8	**18.8**
Swine:	Full feeding										
	Sows	-	87.1	16.1	5.2	5.5	73.2	1.2	-	64.2	**17.5**
	Weaners	-	87.4	18.8	5.7	5.5	70.0	1.3	-	2.1	**16.5**
	Fattening pigs	-	86.9	17.0	4.7	5.1	73.3	1.2	-	9.6	**17.3**

X) Emission of CH_4 from enteric fermentation, tonnes.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Dairy cattle	113 690	109 562	102 825	98 746	96 916	96 197	96 185	92 920	94 581	93 737	93 409	93 217	88 450	88 870	84 265	82 519	82 581
Non-dairy cattle	53 747	51 416	48 552	47 301	46 431	47 752	48 482	49 160	49 201	46 991	47 193	46 994	45 841	44 625	43 329	42 874	44 449
Sheep	682	898	1 019	1 252	1 428	1 579	1 829	1 759	1 516	1 374	1 386	1 615	1 648	1 733	1 816	1 918	2 037
Goats	116	114	113	111	110	108	107	106	104	103	101	100	98	112	117	122	137
Horses	3 053	3 032	3 010	2 988	2 966	2 944	2 977	3 010	3 043	3 075	3 108	3 141	3 173	3 206	3 239	3 272	3 381
Sows	2 275	2 325	2 263	2 210	2 165	2 216	2 275	2 455	2 552	2 431	2 488	2 477	2 619	2 759	2 680	2 737	2 938
Weaners	987	1 043	1 043	1 063	1 060	1 111	1 233	1 395	1 600	1 681	1 668	1 688	1 758	2 008	2 008	1 980	2 070
Fattening pigs	6 232	6 586	6 588	6 711	6 697	7 015	7 246	7 690	8 337	8 016	7 901	7 942	8 159	8 596	8 586	8 463	9 147
Poultry[2]	57	58	52	56	56	59	53	58	60	75	67	70	63	56	58	57	56
Fur animals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pheasant	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Deer	112	118	124	124	124	124	124	124	124	124	124	124	124	124	124	124	132
Ostrich	NO	NO	NO	NO	NO	NO	NO	NO	0.03	0.05	0.08	0.10	0.13	0.15	0.18	0.20	0.23
Sum	180 951	175 153	165 590	160 562	157 953	159 105	160 511	158 678	161 118	157 608	157 447	157 367	151 934	152 091	146 223	144 067	146 929

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dairy cattle	82 022	81 990	78 813	80 116	78 801	78 735	80 529	83 196	83 880	82 513	86 129	86 075	86 508	86 592	89 162	90 735	91 500
Non-dairy cattle	42 372	40 498	38 772	37 300	38 419	41 160	41 558	39 722	40 541	40 853	41 434	42 717	42 141	41 089	40 702	39 809	39 276
Sheep	2 017	2 079	2 133	2 169	2 194	2 126	2 018	1 984	1 907	1 606	1 552	1 519	1 511	1 445	1 424	1 404	1 408
Goats	134	145	156	162	173	181	202	225	229	180	184	186	171	161	161	161	148
Horses	3 490	3 599	3 708	3 817	3 926	4 035	4 144	3 871	3 599	3 381	3 381	3 272	3 272	3 381	3 544	3 708	3 817
Sows	2 957	3 132	3 142	3 148	3 125	3 227	2 964	3 078	3 201	3 076	2 935	3 038	2 947	2 944	2 819	2 837	2 901
Weaners	2 160	2 075	2 222	2 257	2 367	2 437	2 551	2 428	2 488	2 572	2 552	2 393	2 505	2 589	2 656	2 630	2 701
Fattening pigs	9 372	9 321	9 665	9 167	9 155	9 427	8 748	8 366	8 564	8 675	8 107	8 111	8 371	8 282	8 097	7 975	8 170
Poultry[2]	55	63	63	70	60	57	63	56	60	66	63	59	56	60	64	62	66
Fur animals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pheasant	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Deer	123	120	120	119	119	121	119	118	118	100	89	97	92	95	91	88	95
Ostrich	0.15	0.11	0.10	0.08	0.08	0.01	0.01	0.01	0.01	0.004	0.004	0.003	0.002	0.002	0.002	0.002	0.002
Sum	144 702	143 022	138 795	138 327	138 340	141 506	142 896	143 046	144 586	143 022	146 425	147 466	147 572	146 637	148 721	149 408	150 082

NO – not occurring

X) *Continued…*

	2019	2020	2021	2022	2023
Dairy cattle	91 112	89 269	91 338	89 844	88 611
Non-dairy cattle	38 354	38 536	38 165	37 481	36 259
Sheep	1 508	1 375	1 346	1 306	1 280
Goats	168	149	147	148	151
Horses	3 817	4 435	4 438	4 447	4 374
Sows	2 820	2 985	2 967	2 785	2 605
Weaners	2 626	2 661	2 641	2 501	2 294
Fattening pigs	7 670	8 168	8 358	7 732	6 214
Poultry[2]	70	73	73	70	70
Fur animals	0	0	NO	NO	0
Pheasant	0.3	0.3	0.3	0.3	0.3
Deer	97	84	83	79	68
Ostrich	0.002	0.002	0.002	0.002	0.003
Sum	148 241	147 734	149 557	146 393	141 926

NO – not occurring

Y) Emission of CH_4 from manure management, tonnes.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Dairy cattle	30 678	30 373	29 200	28 571	28 752	29 141	29 419	28 931	29 677	29 721	30 442	30 997	31 195	32 657	31 226	35 445	35 502
Non-dairy cattle	23 713	23 685	23 310	23 484	23 871	25 601	26 903	28 430	28 823	27 677	28 328	28 573	28 133	27 294	26 631	26 821	28 612
Sheep	31	41	47	58	66	73	84	81	70	63	64	74	76	80	83	88	94
Goats	6	6	6	6	6	6	5	5	5	5	5	5	5	6	6	6	7
Horses	638	633	629	624	620	615	622	629	636	643	649	656	663	670	677	684	706
Sows	19 681	19 912	19 162	18 511	17 947	18 162	18 412	19 988	20 952	20 092	20 978	21 281	22 929	23 827	23 566	24 676	26 026
Weaners	4 583	5 000	5 152	5 408	5 551	5 982	6 518	7 258	8 040	8 186	8 176	8 332	8 744	9 635	9 700	9 540	9 950
Fattening pigs	692	801	881	1 062	1 133	845	792	857	580	694	707	737	854	909	813	820	882
Poultry[2]	474	483	455	481	514	521	526	558	599	669	631	611	606	603	640	637	647
Fur animals	692	801	881	1 062	1 133	845	792	857	580	694	707	737	854	909	813	820	882
Pheasant	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Deer	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Ostrich	NO	NO	NO	NO	NO	NO	NO	NO	2	4	6	8	10	12	14	15	17
Sum	81 189	81 738	79 725	79 268	79 594	81 793	84 075	87 596	89 966	88 451	90 696	92 012	94 070	96 603	94 170	99 553	103 327

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dairy cattle	36 693	38 184	38 081	38 920	37 320	34 744	35 569	37 052	37 552	36 764	39 527	39 964	39 476	39 421	39 948	39 808	40 074
Non-dairy cattle	28 420	27 917	28 787	27 034	26 975	27 915	28 450	27 645	28 266	28 999	28 539	27 314	26 901	26 739	26 757	26 500	26 344
Sheep	93	96	98	100	101	98	93	91	88	74	69	67	67	64	63	62	62
Goats	7	7	8	9	9	10	11	12	12	9	9	10	9	8	8	8	8
Horses	729	703	724	746	767	788	809	756	703	660	660	639	639	660	692	724	746
Sows	27 362	29 074	29 198	26 819	24 110	22 523	20 707	21 308	22 081	21 111	20 032	19 346	20 115	20 024	19 209	19 263	20 113
Weaners	10 371	10 396	10 777	11 964	11 025	12 415	12 481	12 681	13 184	13 502	13 319	12 127	12 505	12 868	13 208	13 133	13 501
Fattening pigs	821	847	917	1 053	1 179	1 301	1 317	1 352	1 371	1 463	1 565	1 575	1 673	1 710	1 570	1 651	1 487
Poultry[2]	646	677	700	658	586	591	609	581	597	580	582	546	526	536	562	546	564
Fur animals	821	847	917	1 053	1 179	1 301	1 317	1 352	1 371	1 463	1 565	1 575	1 673	1 710	1 570	1 651	1 487
Pheasant	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Deer	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
Ostrich	11	8	7	6	6	1	1	1	1	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.2
Sum	105 976	108 757	110 216	108 364	103 259	101 687	101 366	102 833	105 226	104 627	105 869	103 164	103 586	103 742	103 590	103 349	104 386

NO – not occurring

Y) *Continued…*

	2019	2020	2021	2022	2023
Dairy cattle	38 713	38 344	38 510	37 477	35 042
Non-dairy cattle	26 048	26 158	25 721	25 045	24 226
Sheep	67	61	60	58	57
Goats	9	8	7	8	8
Horses	746	832	833	835	821
Sows	19 120	20 114	20 019	18 699	17 381
Weaners	13 247	13 452	13 783	13 125	12 076
Fattening pigs	1 187	1 068	0	0	4
Poultry[2]	601	618	580	553	564
Fur animals	1 187	1 068	NO	NO	4
Pheasant	0.4	0.4	0.4	0.4	0.4
Deer	1	1	1	1	1
Ostrich	0.2	0.2	0.2	0.1	0.2
Sum	100 928	101 725	99 515	95 800	90 184

NO – not occurring

Z) Volatile soils, VS daily excretion, kg DM per head per day.

Livestock category	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Dairy cattle	5.52	5.55	5.57	5.59	5.63	5.66	5.69	5.72	5.76	5.79	5.82	5.85	5.97	6.09
Non-dairy cattle (weighted average)	1.77	1.80	1.84	1.90	1.94	1.99	2.05	2.09	2.15	2.18	2.21	2.25	2.28	2.30
Calves, bull	1.49	1.49	1.49	1.50	1.50	1.50	1.50	1.50	1.51	1.51	1.51	1.51	1.51	1.51
Calves, heifer	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.69	1.69	1.69	1.69	1.69	1.69	1.70
Bulls > ½ year	1.29	1.39	1.48	1.58	1.69	1.79	1.89	1.99	2.09	2.20	2.31	2.40	2.50	2.61
Heifer > ½ year	1.96	2.01	2.06	2.11	2.16	2.21	2.26	2.32	2.37	2.42	2.47	2.54	2.56	2.56
Suckling cows	6.93	6.90	6.87	6.84	6.81	6.79	6.76	6.73	6.70	6.67	6.65	6.62	6.59	6.56
Sheep	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Swine (weighted average)	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06
Sows (incl. pigs < 7.4 kg)	0.58	0.58	0.57	0.56	0.55	0.55	0.54	0.54	0.55	0.55	0.57	0.58	0.59	0.61
Weaners (7.4 – 32 kg)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Fattening pigs (32 – 107 kg)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Goats (mother goats incl. kids)	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24
Horses	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90
Poultry (weighted average)	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.003
Hens	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Pullet	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Broilers	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Turkeys, geese and ducks	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02
Deer	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Fur animals	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Ostrich	NO	NO	NO	NO	NO	NO	NO	NO	1.13	1.13	1.13	1.13	1.13	1.13
Pheasant	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Z) *Continued…*

Livestock category	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Dairy cattle	6.09	6.15	6.15	6.35	6.49	6.62	6.72	6.59	6.26	6.20	6.34	6.37	6.22	6.36
Non-dairy cattle (weighted average)	2.32	2.36	2.41	2.43	2.74	2.76	2.81	2.85	2.83	2.85	2.87	2.88	2.85	2.85
Calves, bull	1.51	1.51	1.53	1.53	1.53	1.53	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54
Calves, heifer	1.70	1.70	1.69	1.69	1.70	1.70	1.71	1.71	1.81	1.81	1.81	1.81	1.81	1.81
Bulls > ½ year	2.65	2.76	2.90	3.01	3.05	3.20	3.42	3.64	3.85	3.91	4.05	4.06	3.94	3.91
Heifer > ½ year	2.56	2.58	2.60	2.60	2.62	2.74	2.76	2.77	2.88	2.89	2.89	2.91	2.93	2.93
Suckling cows	6.56	6.60	6.63	6.93	7.04	6.50	6.40	6.16	4.72	4.78	4.83	4.84	4.82	4.86
Sheep	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.49
Swine (weighted average)	0.06	0.06	0.06	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05
Sows (incl. pigs < 7.4 kg)	0.62	0.64	0.66	0.70	0.73	0.73	0.65	0.57	0.49	0.48	0.48	0.48	0.48	0.48
Weaners (7.4 – 32 kg)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Fattening pigs (32 – 107 kg)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Goats (mother goats incl. kids)	1.24	1.24	1.24	1.24	1.24	1.24	1.26	1.26	1.27	1.27	1.27	1.27	1.27	1.23
Horses	3.90	3.90	3.90	3.90	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70
Poultry (weighted average)	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003
Hens	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Pullet	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Broilers	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Turkeys, geese and ducks	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Deer	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Fur animals	0.09	0.09	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09
Ostrich	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Pheasant	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Z) *Continued…*

Livestock category	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Dairy cattle	6.43	6.65	6.71	6.81	6.97	7.02	7.12	7.20	7.43	7.42	7.49
Non-dairy cattle (weighted average)	2.66	2.69	2.67	2.67	2.66	2.65	2.67	2.69	2.69	2.67	2.67
Calves, bull	1.54	1.54	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.52	1.52
Calves, heifer	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.80	1.80	1.80	1.80
Bulls > ½ year	2.75	2.81	2.79	2.79	2.74	2.67	2.73	2.77	2.73	2.55	2.54
Heifer > ½ year	2.97	2.98	2.98	3.01	3.03	3.06	3.09	3.09	3.12	3.14	3.15
Suckling cows	4.90	4.92	4.93	4.95	4.95	4.97	4.97	5.00	5.01	5.04	5.08
Sheep	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Swine (weighted average)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sows (incl. pigs < 7.4 kg)	0.48	0.47	0.47	0.47	0.47	0.48	0.47	0.47	0.47	0.47	0.47
Weaners (7.4 – 32 kg)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Fattening pigs (32 – 107 kg)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Goats (mother goats incl. kids)	1.23	1.23	1.23	1.23	1.23	1.23	1.22	1.22	1.22	1.22	1.22
Horses	3.70	3.70	3.70	3.70	3.70	3.70	3.70	4.00	4.00	4.00	4.00
Poultry (weighted average)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Hens	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Pullet	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Broilers	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Turkeys, geese and ducks	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Deer	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Fur animals	0.10	0.10	0.10	0.10	0.10	0.09	0.10	0.10	NO	NO	0.11
Ostrich	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Pheasant	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

AA) Above-ground residue dry matter AGDM(T), kg DM per ha.

kg DM per ha	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Winter wheat	8 031	8 488	7 914	9 351	10 025	10 209	9 747	8 507	9 623	8 959	10 407	9 667	9 989	10 045
Spring wheat	4 852	5 551	4 941	5 368	5 385	5 932	5 528	4 093	5 562	5 320	5 740	6 633	5 209	5 841
Rye	4 156	4 219	3 507	4 228	4 515	4 653	4 593	3 240	4 211	4 459	4 788	4 209	4 748	4 830
Winter barley	3 730	4 420	4 172	4 930	5 534	5 197	4 869	4 139	4 702	4 600	5 079	4 504	4 943	4 833
Spring barley	4 015	3 941	3 765	3 871	4 061	4 504	4 422	2 439	3 713	3 928	4 360	4 249	4 206	4 394
Oats	3 224	3 385	3 461	3 679	3 384	4 635	4 528	2 497	3 805	4 003	4 800	4 815	3 987	4 350
Triticale and other grains	0	0	0	0	0	0	0	0	0	0	0	0	4 982	4 511
Maize	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize (animal feed)	14 273	12 199	7 895	15 697	15 156	15 861	13 894	14 589	13 287	14 518	14 322	13 133	13 130	10 781
Potato	870	884	777	903	888	900	808	795	899	841	817	899	944	985
Alfalfa	2 855	2 728	2 756	2 890	2 844	3 033	2 828	2 441	2 847	2 638	2 902	2 404	3 824	4 108
Beans and pulses	4 113	3 680	2 455	3 332	3 729	4 636	4 066	2 468	3 633	3 595	3 664	3 576	3 885	3 503
Tubers	941	646	744	964	972	1 034	972	893	1 039	932	881	856	923	963
Non N fixing forages	2 635	2 762	2 540	2 868	2 935	3 517	3 377	1 977	2 677	2 649	2 834	4 332	3 403	2 039
N fixing forages	5 456	3 926	4 061	4 022	3 691	4 241	4 068	2 170	2 626	2 653	2 800	3 801	2 859	1 740
Perennial grasses	870	841	843	919	890	904	851	771	881	520	854	841	992	1 015
Grass-clover mixtures, in rotation	2 534	2 340	2 420	2 640	2 436	2 667	2 496	2 105	2 220	1 920	2 397	2 275	2 360	2 487
Grass-clover mixtures, outside rotation	1 740	1 683	1 686	1 839	1 779	1 808	1 702	1 541	1 763	1 040	1 707	1 682	1 984	2 031
Rapes	2 192	2 184	1 741	2 024	2 287	2 372	2 109	1 823	2 062	1 767	1 650	1 877	2 216	2 525

AA) *Continued…*

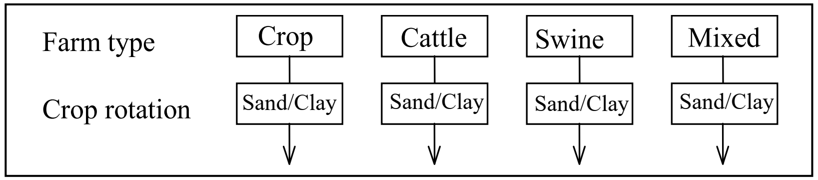
kg DM per ha	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Winter wheat	9 922	10 414	10 139	9 723	9 768	9 887	9 926	9 568	8 970	10 668	11 263	9 191	8 964	10 160
Spring wheat	5 218	5 856	5 080	4 335	4 783	4 316	4 773	3 518	5 188	4 063	5 133	5 095	4 653	5 462
Rye	4 669	4 820	4 735	4 603	4 780	4 311	4 296	4 049	4 173	4 532	5 229	4 598	4 862	6 191
Winter barley	4 892	4 706	4 852	4 666	4 934	5 023	4 981	4 631	4 224	4 942	5 532	4 580	4 605	5 186
Spring barley	4 222	4 493	4 390	4 115	4 353	4 161	4 382	3 752	4 095	3 794	4 616	4 303	4 467	4 557
Oats	3 895	4 054	3 793	3 896	4 094	4 392	4 183	3 518	4 339	3 467	4 568	5 066	4 111	4 588
Triticale and other grains	4 460	4 145	3 734	3 119	3 678	3 657	3 304	4 407	4 319	4 690	4 842	4 549	4 811	5 308
Maize	0	0	0	0	0	0	0	0	0	0	0	0	5 142	5 320
Maize (animal feed)	12 332	11 636	12 367	12 851	12 311	11 515	12 029	13 185	12 604	13 371	13 778	12 149	13 238	11 574
Potato	951	1 022	971	960	941	954	936	862	947	967	1 021	882	960	961
Alfalfa	3 978	3 851	3 745	3 568	3 249	3 364	3 264	3 316	3 616	3 100	3 203	3 219	3 063	3 632
Beans and pulses	2 819	3 742	3 410	3 583	3 842	3 476	3 226	2 731	3 313	2 746	3 407	3 145	3 671	4 082
Tubers	988	986	978	1 018	994	1 000	993	951	982	1 026	893	1 045	1 142	1 033
Non N fixing forages	1 642	2 421	2 572	2 376	2 268	2 249	2 251	2 184	2 295	1 976	2 204	2 171	2 476	2 336
N fixing forages	1 405	2 047	2 194	1 971	1 881	1 865	1 867	1 811	1 903	1 638	1 828	1 800	2 053	1 937
Perennial grasses	950	901	888	783	754	734	683	727	650	654	719	644	664	651
Grass-clover mixtures, in rotation	2 382	2 408	2 373	2 331	2 155	2 170	2 441	2 405	2 677	2 576	2 885	2 842	2 989	2 963
Grass-clover mixtures, outside rotation	1 900	1 803	1 776	1 565	1 508	1 468	1 365	1 455	1 300	1 309	1 438	1 288	1 329	1 302
Rapes	2 225	2 298	2 153	2 111	2 709	3 131	2 454	2 836	2 662	2 952	3 208	2 849	2 709	3 100

AA) *Continued…*

kg DM per ha	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Winter wheat	10 092	10 676	11 146	9 905	11 244	8 491	11 326	11 375	10 462	11 804	10 099
Spring wheat	5 643	4 585	6 211	5 722	5 710	4 381	6 072	5 996	5 148	5 506	4 261
Rye	5 536	6 034	5 696	5 404	6 162	4 966	5 716	5 702	5 821	5 789	5 238
Winter barley	5 091	4 532	5 875	5 061	5 551	4 456	5 849	5 914	5 325	5 999	5 264
Spring barley	4 711	4 684	4 842	4 557	4 797	3 588	5 035	5 294	4 609	5 638	3 625
Oats	4 530	4 818	4 736	4 516	4 775	2 985	4 280	4 838	4 354	4 905	3 295
Triticale and other grains	5 522	6 112	4 917	5 790	6 867	4 753	5 432	5 993	6 804	6 128	5 286
Maize	5 826	6 975	6 588	6 892	6 990	5 255	7 535	5 703	6 606	6 841	5 687
Maize (animal feed)	12 816	14 030	10 625	12 764	13 268	12 082	13 564	13 347	13 541	13 993	12 713
Potato	979	1 012	1 024	1 070	1 109	893	1 080	1 059	1 037	1 099	1 083
Alfalfa	3 810	3 712	3 282	3 465	3 524	1 349	3 494	3 439	3 259	3 443	2 030
Beans and pulses	2 994	3 636	4 047	3 596	4 160	2 531	3 839	3 944	3 269	4 038	2 783
Tubers	882	1 006	1 139	1 171	1 226	920	1 284	1 286	1 290	1 250	1 271
Non N fixing forages	2 373	2 340	2 174	2 241	2 266	1 842	2 328	2 373	1 961	2 199	1 512
N fixing forages	1 968	1 940	1 803	1 858	1 879	1 528	1 930	1 968	1 626	1 824	1 254
Perennial grasses	540	616	654	712	479	586	429	409	412	296	238
Grass-clover mixtures, in rotation	2 569	2 702	2 886	3 036	3 050	2 058	2 383	2 453	2 429	2 325	1 877
Grass-clover mixtures, outside rotation	1 081	1 232	1 307	1 425	959	1 172	858	817	825	592	475
Rapes	3 190	3 472	3 474	2 492	3 384	2 719	3 559	3 103	3 187	3 656	3 141

AB) Model calculation of nitrogen leaching nationwide by SKEP/DAISY and N-LES.

Basic DAISY calculations of N leaching



<u>Each crop rotation calculates for:</u>
6 climate regions
30 fertilizer plan
4 soil type (here 2 w/w.out water)

} 38.000 combinations

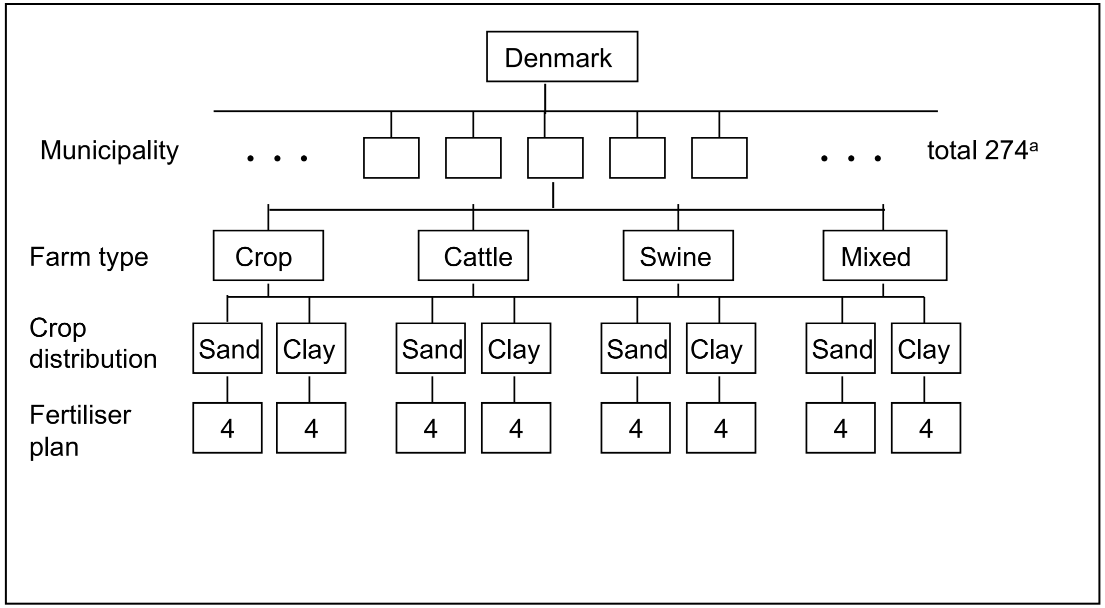
<u>Data base</u>
Calculation for all combinations for each of 4 climate year
Calculation for 12 combinations for each year in an 11 years period (1989-2001).

N-LES calculations

Model calculations for the crop rotations and fertiliser planes in SKEP plus appurtenant percolations from the DAISY calculations. Model calculations for each of the 11 years in the period 1989-2001, mean of the 11 years is up scaled nationwide by SKEP

Upscaling by the SKEP model

In the up scaling of DAISY calculations, a climate normalisation and yield correction is made
[a] former municipality division



AC) QA/QC procedure. stage I – III.

Stage I: Check of input data	**Variable**	**Reference**
Livestock production	- number of animals	Statistics Denmark
	- slaughter data	
Normative standards	- N excretion	DCA
	- use of straw	
	- amount of manure	
	- feed intake	
	- milk yield	
Barn types	- distribution	SEGES + SGAV
Grazing days		SEGES
Crops	- land use	Statistics Denmark
	- crop yield	
	- crop production	
Synthetic fertiliser	- N content	LFST
	- fertiliser types	
N leaching	- amount of nitrogen leached	DCE
Atmospheric deposition	- all NH_3 emission sources	DCE – NH_3 inventory
Sewage sludge and industrial waste	- amount of sludge applied to soils	DEPA
Industrial waste	- amount of sludge applied to soils	SGAV
Biomass other than manure	- amount of biomass	DEA
Stage II: Check of IDA data – overall	**Emission source**	**Variable**
Recalculation	- CO_2–eqv. total emission	- compared with latest submission
	- CH_4, N_2O, CO_2, NH_3, NOx, NMVOC, PM	
	- emission from field burning	
Time series	- CO_2–eqv. total emission	- trends
	- CH_4, N_2O, CO_2, NH_3, NOx, NMVOC, PM	- jumps and dips
Recalculation	- CO_2–eqv. total emission	- compared with latest submission
Stage III: Check of IDA data – specific	**Emission source**	**Variable**
CH_4	- enteric fermentation	- IEF (jumps and dips)
		- Ym (dairy cattle + heifer)
		- GE
CH_4, N_2O, NH_3, NOx, NMVOC, PM	- manure management	- IEF (jumps and dips)
		- VS
		- Nex
N_2O, NH_3, NOx, CO_2	- synthetic fertiliser	- trends (jumps and dips)
		- IEF
N_2O, NH_3, NOx, NMVOC	- animal waste applied to soil; pasture, range and paddock	- trends (jumps and dips)
		- IEF
N_2O, NH_3	- crop residue	- trends (jumps and dips)
		- IEF
N_2O	- atmospheric deposition; N leaching and run-off; mineralisation; organic soils	- trends (jumps and dips)
		- IEF
N_2O, NH_3, NO_X	- sewage sludge; industrial waste; biomass	- trends (jumps and dips)
		- IEF
NH_3, NMVOC	- crops	- trends (jumps and dips)
CO_2	- liming	- trends (jumps and dips)

DANISH EMISSION INVENTORIES
FOR AGRICULTURE

Inventories 1985–2023

Regulations in international conventions obligate Denmark to prepare annual emission inventories and document the methodologies used to calculate emissions. The responsibility for preparing the emission inventories for agriculture is undertaken by the Danish Centre for Environment and Energy (DCE), Aarhus University, Denmark. This report contains a description of the emissions from the agricultural sector from 1985 to 2023 and includes a detailed description of methods and data used to calculate the emissions, which is based on international guidelines as well as national methodologies. Emissions are calculated for both greenhouse gases and air pollutions. The agricultural NH_3 emission from 1985 to 2023 has decreased from 162 tonnes NH_3, corresponding to a reduction of approximately 61 %. The emission of greenhouse gases in 2023 is estimated at 11.2 million tonnes CO_2 equivalents and reduced from 15.3 million tonnes CO_2 equivalents in 1985. Since 1990, which is the base year of the Kyoto Protocol, a reduction of 23 % is obtained.

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